Power Generation and POWER PLANT ENGINEERING

For ALL Power Engineers • Steam, Electricity and All Other Power Engineering Services

COMPLETE CONTENTS

★ **Design of Purging Systems For Hydrogen Cooled Electric Machines** 54
By D. S. Snell and R. C. Schmid

How to Select Correct Diesel Starting Battery 66

Annapolis Gas Turbine Operates Successfully at 1500 F 67

★ **New Boiler Plant for Kutztown State Teachers College** 68
By G. L. Yeakel

Looking for Reddy Kilowatt in Trenton Channel's New Unit No. 7 72

★ **Mobile Equipment Facilitates Power Line Pole Replacement** 74
By John M. Green

Relation of Plant Design To Reserve Capacity 76
By M. J. Steinberg

When Doctors Disagree on Densities of Gases 79
By J. R. Darnell

Basic Power Plant Figuring 80
By William H. Engelman

★ **How Marion Power Shovel Co. Modernized Its Steam Plant** 82
By G. R. Kilbourn

Atomics Digest 88

Shrink Links and Bolts in Power Plant Erection 96
By H. B. McDermid

New Uses of Fly Ash May Eliminate Costly Disposal Problem 101

What Is Engineering? 101
By C. H. Morrow

Regular Departments

Notes on This Issue 5

Engineers' Preview 7

Helpful Bulletins 35

New Equipment News 42

Letters to the Editors 53
Balancing Rotors
The New Era
Power Generation on Microfilm for Libraries

Questions and Answers 90
Should He Use Accumulator on Lines To Steam Presses?
How Do You Test a Ladder?

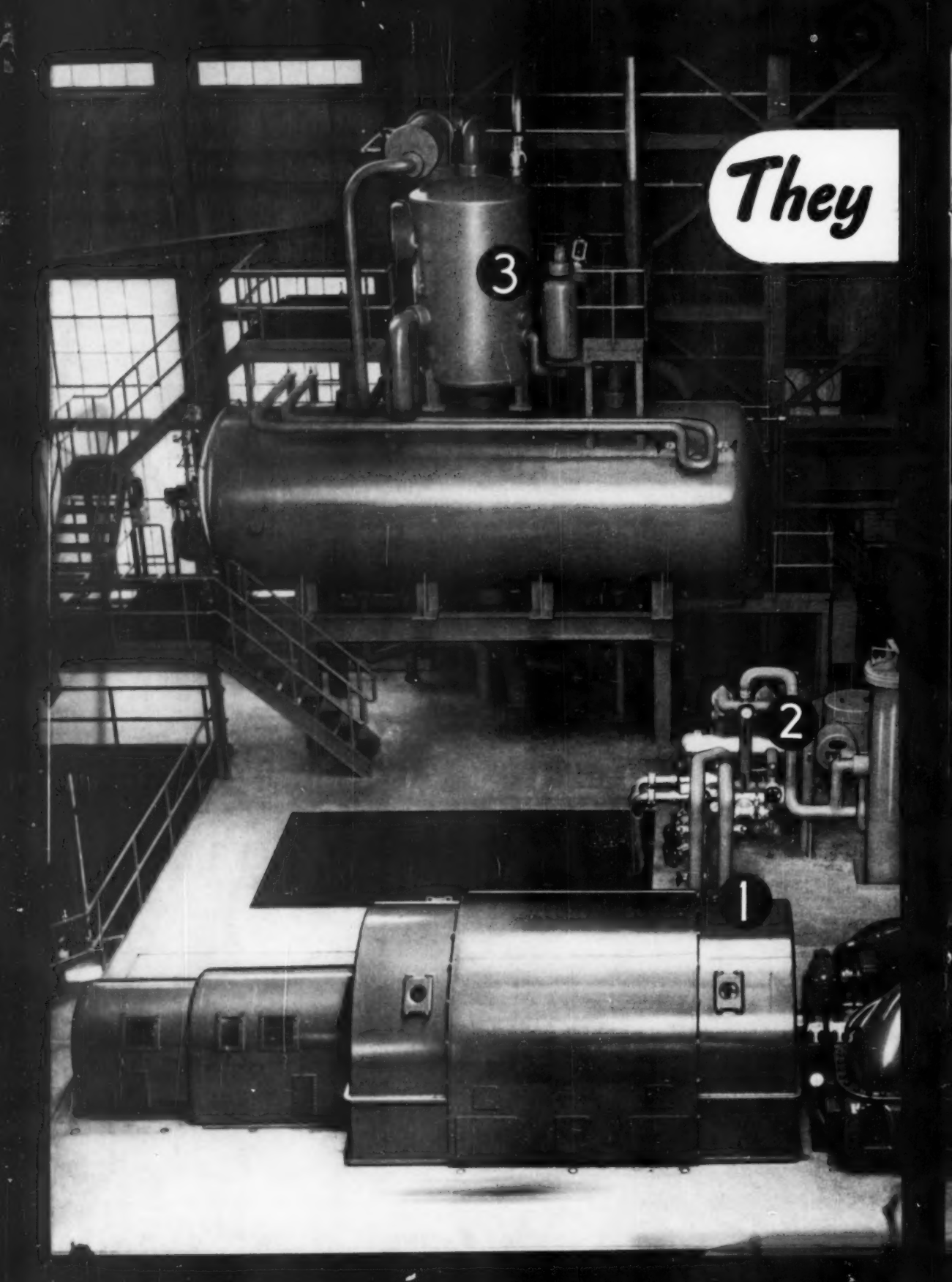
New Engineering Books 102

Coming Events 102

Catalog Library 103

Construction News 50

FEBRUARY
1950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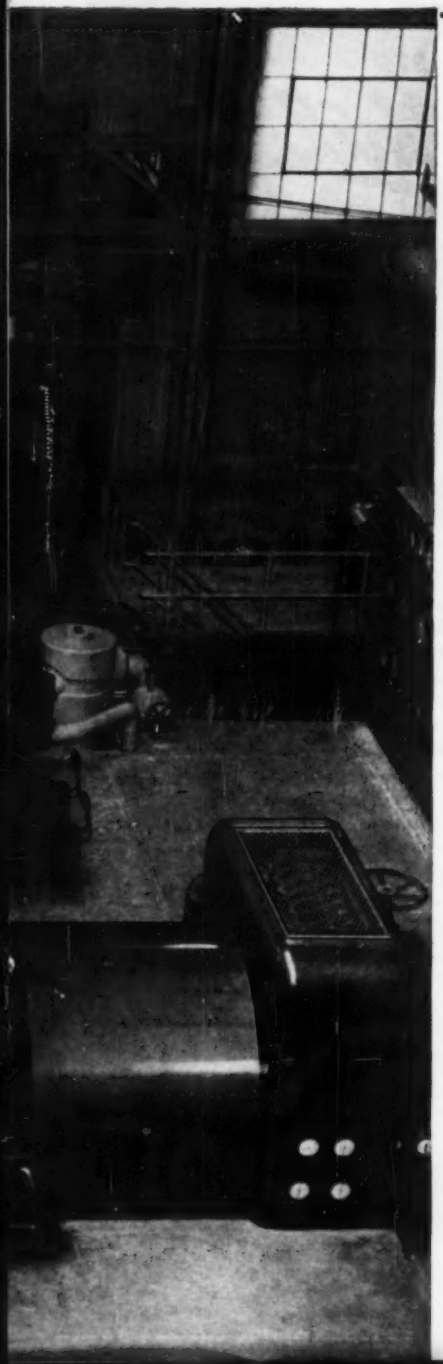

ELLIOTT

❶ In the foreground, an Elliott turbine-generator unit — clean-lined, businesslike, and all-Elliott throughout . . .

❷ Just back of the turbine-generator, an Elliott twin two-stage steam jet ejector which serves the Elliott surface condenser under the main turbine . . .

❸ In the background, the Elliott vertical deaerating feedwater heater mounted on its horizontal storage tanks, unsleeping sentinel against corrosive elements in the boiler feedwater . . .

And not shown in the photo, but definitely in the picture of operating economy, is an Elliott evaporator preheater quietly and faithfully performing its function.

This plant, generating at 13.8 kv, with 600 psi, 825 F steam conditions, is typical of a score of utility installations where Elliott equipment has gone into service recently.

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Complete data on any of this equipment mailed at your request.

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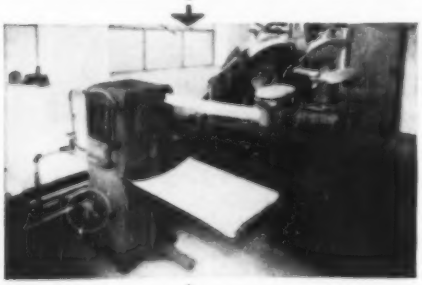
Q-1149a

"How to get new steam traps for free"

Trade steam losses for them . . .

Cost of Steam Leaks at 100 Pounds Pressure
(Assuming steam costs 50 cents per 1000 lbs.)

Size of Orifice	Lbs. Steam Wasted Per Month	Total Cost Per Month	Total Cost Per Year
1/2"	835,000	$417.50	$5,010.00
3/8"	470,000	235.00	2,820.00
1/4"	210,000	105.00	1,260.00
1/8"	52,500	26.25	315.00
1/16"	13,200	6.60	79.20
1/32"	3,400	1.70	20.40



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IT COSTS far more to live with leaky steam traps than it does to replace them with Armstrongs — the traps that pass no steam. Measure their cost against steam losses caused by traps that let steam get by (see left).

In Armstrong traps the discharge valve is water-sealed at all times—no steam gets to it. There's no chance for dirt to hold the valve open and let steam escape. Armstrong traps don't COST money, they SAVE money. Ask your nearby Armstrong representative to figure on the traps you need now.

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Power Generation

February 1950

VOLUME 54—NUMBER 2

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Notes on This Issue

Purging Systems for Hydrogen Cooled Electric Machines

Today, all generators over 20,000 kw are hydrogen cooled so purging is of importance and interest to a very large number of our readers.

This twelve page feature section is without question the most comprehensive and authoritative treatise ever published on the subject, and it is exclusive in POWER GENERATION. Purging, if done correctly, is a complex procedure involving a large amount of data as indicated by the curves and calculations in this article. Engineers in every part of the country will find this material of inestimable practical value. The article presents all of the crystallized knowledge on the subject accumulated over the past twenty years by Mr. Snell and Mr. Schmid.

New Boiler Plant for Kutztown State Teachers College

Mr. G. L. Yeakel was the supervising engineer on this project for Gilbert Associates, Inc., of Reading, Pa. With his detailed knowledge of the whole project from its inception he has written a very interesting account of all the steps involved in the extension and rehabilitation of this small but fine boiler plant.

This is an extremely high-grade plant, not so small at that, since it contains three 15,000 lb per hr boilers. The equipment is most modern and the way the old building was utilized and improved to conform with modern architectural lines forms an interesting story.

It is of interest to all small plant operators and to consulting engineers.

Mobile Equipment Facilitates Power Line Pole Replacement

Transmission and distribution engineers who know the joys of changing poles with several thousands of volts charging along merrily overhead will appreciate this two page picture story. It shows, step by step, how simple mobile equipment was used by Indianapolis Power & Light Co. to overhaul all their pole lines, lower cross arms where necessary and replace many 55 to 70 ft poles without interrupting service.

Those Engelman Articles

A POWER GENERATION fan hands Mr. Engelman (and us) a very sincere compliment in the following letter:

"Gentlemen: May I offer my congratulations to your organization for publishing the articles by Mr. W. H. Engelman. They must surely go a long way toward taking the mystery out of power plant engineering for the operator who has not had, or availed himself of, the opportunity for education along these lines.

Being one of the fortunate group that had the full course under the able teaching of Mr. Engelman I cannot help but regret that every operating engineer has not had the same opportunity.

"With the publication in your magazine, that has such a wide circulation. I hope these articles will serve as the impetus for the establishment of other schools. If such should be the case you will certainly merit a great deal of credit for any success they may have.

Yours truly, H.K.L."

In this issue the article covers steam and water flows in surface condensers and steam turbines.

Plant Design for Reserve Capacity

For some years, now, there has been a trend in central station design toward the use of the single boiler—single turbogenerator unit arrangement, for unit operation. This arrangement, true, makes for least investment for plant capacity but it does not necessarily represent the most economical choice when considered in relation to basic requirements for system reserve, overhaul requirements, and availability of plant capacity for base load operation.

This article is a study and analysis of this problem. Mr. M. J. Steinberg assumes a number of different possible arrangements of units for a 640 Megawatt plant to be connected to an existing system. Each case is discussed individually and the results of the analysis expressed in tables and graphs. His results are interesting and the article should be of value to engineers throughout the entire utility industry.

Plant Electrics

Breezy and useful comments on the joys and sorrows of the plant electrical engineer in the industrial and institutional types of plant.

CHEMICAL TREATMENT METERING PUMPS

for Every Power Plant

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ENGINEERS' PREVIEW

TO MAKE some of industry's products smell better —and sell better—the Du Pont Co. now has available commercial quantities of a new series of odorants for rubber and related products. They may be used in: Foam rubber products such as pillows, mattresses, and seat cushions; latex-bonded upholstery and rug-backing fibers to deodorize both rubber and fibers; rubber-containing adhesives; such rubber goods as dress shields, gloves, girdles, hot water bottles, and toys; certain plastics.

Odorants are available for natural and synthetic rubber, including neoprene. The company is making a series of them under the trade-mark "Alamask." They may be employed singly or in combination, and concentrations from one-tenth to one-hundredth of one per cent, added during the manufacturing process, are sufficient.

★ ★ ★

CRIME NEVER PAYS—everybody knows that. Consider the story of the young lady who put out the fire and was fined $25 for doing so. It comes from the ineffable city of Pasadena, through the *Los Angeles Times*, relayed by *Firefax*.

It seems there was a young lady named Gloria H. Miller who had an apartment. One day she looked at the davenport in her apartment and observed that it was on fire. She doused a glass or two of water on the flame and extinguished it.

Next day, the Pasadena Fire Marshal, Russell Stone, heard of the fire and Miss Miller, who works for a living, was summoned to Pasadena Municipal Court for violation of Sect. 17830, California State Housing Act. That section says that, when one discovers a fire, one must call the Fire Department before trying to put out the fire. Otherwise one breaks the law.

When Miss Miller appeared in Municipal Court, Justice William Fox fined her $25 for negligence in setting fire to the davenport, presumably from a cigarette, and another $25 for not notifying the Fire Department of the fire. The second fine was suspended. A final interesting touch is that the young lady's landlord, William Berk, paid the first fine, and reduced Miss Mliler's rent 10 per cent because she put out the fire.

★ ★ ★

MANY INCORRECT ideas have been spread among the general public, during the past few years, about the evil effects of air pollution by smoke, dust, fly ash, fumes and the like in causing actual disease, such as cancer or other diseases of the lungs and so on, in human beings. But the fact is that many of these ideas are not in any way confirmed by available evidence. Air pollution is bad—a nuisance that should be eliminated for all sorts of social and economic reasons. But the idea that it is raising havoc with human life is "a gross mis-use of statistics for propaganda purposes." If you doubt it, read the statement on Health Effects of Air Pollution by Dr. A. J. Lanza, presented last year at the 42nd Annual Conference of the Smoke Prevention Association of America and now issued by the association in booklet form. Engineers faced with charges that smoke from their stacks is damaging human life can make good use of it. They have got to abate smoke, but not for that reason. (And don't remind us of Donora.)

WE TOO, have joined the "We've Met Jack Jarvis and We're Not Impressed Association" along with the *Hydromike*, which, as we've told you, is one of our favorite swiping magazines. *Hydromike* reports that Jack, occupant of the night city desk on the Seattle *Post-Intelligencer*, overcomes the frustration of the daily facts of life he must report by unstuffing stuffed shirts, tying knots in tails of sacred cows. He does this on the printing press in his basement by founding more associations and societies than you could shake with laughter at.

He has established the "Committee for the Return of the Five-Cent Cigar," and "The Committee to End Committees—Extremely Active Member Group." His "Association of Veterans Who Don't Join Veterans Associations" spread like wildfire. Another favorite is the "I'm Just Wild About Harry Association, affiliated with the National Order of Band-Wagon Climbers-On." He also issues membership cards in the "Thank God It's Friday Club" and the "Society for the Prevention of Mixing Peas and Carrots." One of Jack's best, we feel, is his certification of a season pass to the men's room at the Union Station in Chicago.

★ ★ ★

GRAND TOTAL of 405 potential irrigation, multiple-purpose, and other projects, are included in the coordinated Department of the Interior-Department of the Army plan for the development of water and land resources of the Columbia River Basin, according to a tabulation just issued by the Bureau of Reclamation this week. The projects, large and small, constitute the total future development of water resources in the Columbia River Basin as currently envisioned by these agencies. Hydroelectric power production is involved in 152 projects. The 141 of these projects for which data are available would have an installed capacity of 19,580,540 kw—more than four times the present installed capacity of the region.

★ ★ ★

POWER ENGINEERING in the public utility fields, and in the manufacturing of electrical and many other kinds of equipment, demands training and experience in both mechanical and electrical engineering, combined with considerable knowledge of basic administrative and business practice. Many of today's power engineers, originally trained in either the mechanical or the electrical fields, have been compelled by the conditions of the industry to master the combination the hard way. They will be interested in learning therefore, that Lehigh University is now establishing a new five-year course designed to point a graduate straight at the power field as it is in practice.

This course is intended to offer a highly integrated, comprehensive and balanced program, whose graduates will be equally proficient in electrical and mechanical engineering and have some grounding in business subjects. The course offers the degree of B. S. in mechanical engineering at the end of four years (in case a student must stop there for financial or other reasons) and a degree of B. S. in electrical engineering at the end of the fifth year. Full information about the course, also about a second new course in combined industrial engineering and business administration may be obtained from Dr. Martin D. Whitaker, president, Lehigh University, Bethlehem, Pa.

ADD TO LIST of specialists: The National Split-Pea Association, just noted in the Chicago telephone directory. Reminds us of the old lady who was informed that one of her grandsons had become a Naval surgeon. "My!" she exclaimed, "How they do specialize nowadays!"

★ ★ ★

WHO AND WHAT is an engineer? How can you distinguish him definitely from anybody else?

There has been a steady increase in specialized branches of engineering during recent years. Some of these are simply specializations in the function of engineering, such as welding engineering, tool and die engineering, petroleum engineering and so on. Others are associated more closely with the basic sciences, for example, geological engineering. Still others tend toward the border line of business, such as administrative engineering.

As a result there exists today some confusion as to what really characterizes an engineer and as to a college curriculum suitable for training him.

This whole question has been very carefully and thoroughly considered for some time by an appropriate committee of the Engineers' Council for Professional Development. At the last meeting of the Council in Chicago, a report of that committee pointed out that the principal problem is to specify the characteristics that differentiate an engineer so that the college curricula can be guided along this direction. In summary, it was felt that the difference between an engineer and a person in an adjoining field consists primarily in ability to design, as a significant and distinctive element. Accordingly, the report proposes the following definition of an engineer:

"An engineer is characterized by his ability to apply scientific principles to design or develop structures, machines, apparatus or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design, and of the limitations of behavior imposed by such design; or to forecast their behavior under specific operating conditions; all as respects a specific function, economics of operation and safety to life or property."

It should be observed that this definition takes full account of the work of both construction and operating engineers in any field. This is extremely important because, as we all know, it is not the title of designer that is important but the understanding of the process of analysis and synthesis essential to designing.

A man in overalls who operates equipment with full knowledge of this design process, even though he is not responsible for it himself, may be considered truly an engineer by the above definition.

Finally, the above definition is not yet official, but has been put forth primarily to stimulate discussion and, if possible, approval.

★ ★ ★

HIGH COST of construction today has increased insurable values. As a result, your present industrial insurance should be adjusted to take this fact into account, develop proper values, revise them at least annually and make a new appraisal at least every five years. Reasons and methods for doing this are given in detail in a new booklet Fire Insurance Values and Appraisals under Today's Conditions, by Ford, Bacon & Davis, Inc. If you want a copy, write the Engineers' Preview editor.

"I WANT to Know *More* About the Electric Industry," the second "I Want to Know" information booklet to be brought out by the Edison Electric Institute, has just been published. Like its predecessor of last year, the new booklet answers in concise form questions frequently asked the Institute and supplements each brief answer with tabular and text material. It is written for the layman and yet contains much of interest to engineers.

Based on national data derived primarily from the EEI's annual *Statistical Bulletin* and from various Federal Power Commission publications, the new booklet presents authoritative answers to a wide range of questions, such as "How Does the U S Rank in World Production and Capacity?", "Who Uses How Much?", "What About Electricity at Home?", "How Many Electrical Appliances Work for U S Families?". "What About Electricity on the Farm?", "Where Do Electric Company Revenues Come From?", "Who Owns the Electric Industry?", "Who Produces and Sells the Greatest Percentage of Electricity?", and "What About the Future?".

★ ★ ★

ATMOSPHERIC CONTAMINATION and Purification was the subject of a very important symposium held last year at the San Francisco annual meeting of the American Chemical Society. The papers included in that symposium, all by outstanding authorities in this field, were published complete in the November 1949 issue of Industrial and Engineering Chemistry, the Journal of the Society. They have now been collected in the form of a 112-page, 8½ by 11-in. paperbound reprint, available at 75 cents per copy.

In our opinion this is one of the most important technical publications on the subject yet published. It forms, in fact, an engineering textbook that is entirely different from much of the general comment usually issued. In these papers, each author gets right down to the most specific, practical, usable details.

While much of it should be of value to executives, its real value is to the power engineer, plant engineer and production engineer who must carry out the actual measures required to prevent atmospheric pollution in a specific plant.

The papers cover: dust and fume standards; legal regulation of air pollution; location of dust-producing areas; dissemination, dispersion and deposition of aerosol particles from stacks; the venturi scrubber; electrical precipitation and mechanical dust collection; agglomeration of aerosol particles by sonic waves and industrial sonic collection systems; effects of SO_2 in the atmosphere; and other allied subjects of interest in air pollution abatement. Many curves, data tables and illustrations of equipment are given, also detailed lists of references to the existing literature.

★ ★ ★

JOINT Committee on Effect of Temperature on the Properties of Metals, which functions under the auspices of the American Society for Testing Materials and The American Society of Mechanical Engineers, has virtually completed reorganization of its subcommittees and personnel. This group, always very active in sponsoring technical papers and symposiums, has several papers and reports under way including two symposiums, one covering The Effect of Sigma Phase on the Properties of Metals at Elevated Temperatures, the other dealing with The Corrosion of Gas Turbine Materials. These symposiums will each include eight to ten papers, and are scheduled for presentation at the ASTM Annual Meeting in Atlantic City the week of June 26, 1950.

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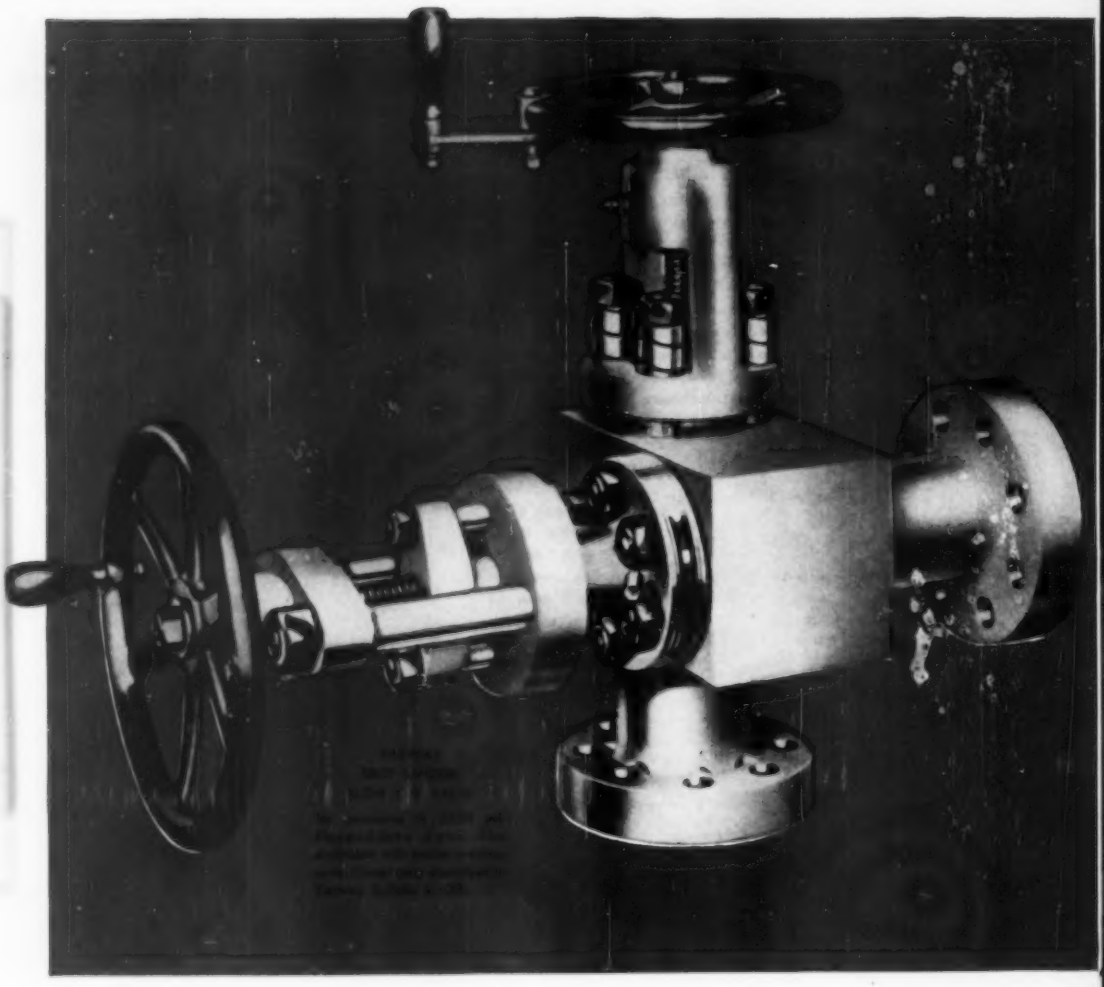

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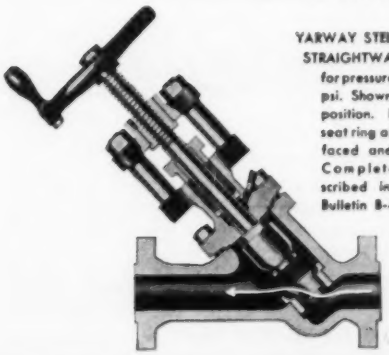
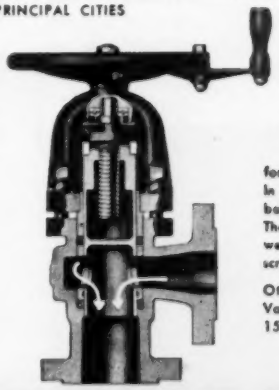
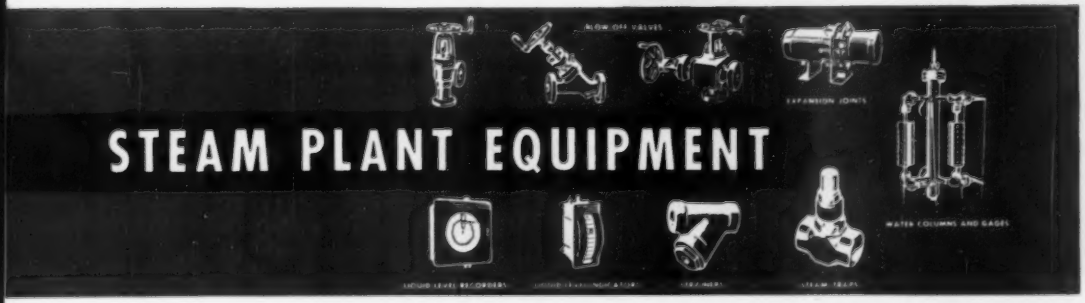


YARWAY STELLITE-SEAT STRAIGHTWAY VALVE for pressures to 2500 psi. Shown in open position. Disc and seat ring are stellite-faced and ground. Completely described in Yarway Bulletin B-432.



YARWAY TYPE "B" SEATLESS ANGLE VALVE for pressures to 400 psi. In open position. Notice balanced sliding plunger. There is no seat to score, wear, clog or leak. Described in Bulletin B-424.

Other Yarway Seatless Valves for pressures to 1500 psi.



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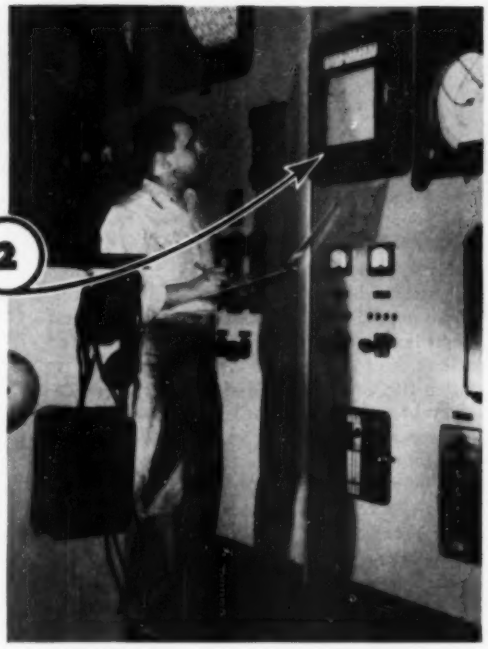

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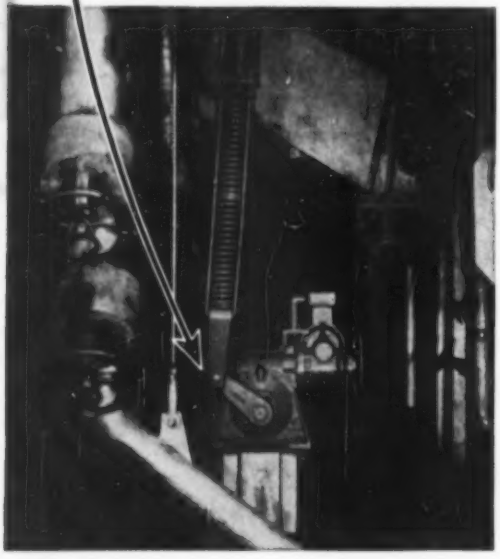
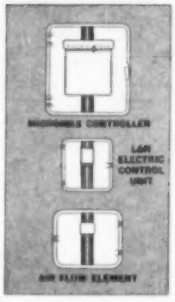


TWO ELEMENT CONTROL anticipates temperature changes even before they reach the thermocouple. Its Air Flow Element makes primary movement of dampers, etc., as soon as boiler load varies; while Micromax Controller follows with final adjustment based on actual steam temperature.

4



Combined in the Micromax system, all elements work together to give outstanding performance on any type of superheater equipment — bypass damper, spray desuperheater, attemperator, desuperheating condenser, burner elevation or any combination of these. For details, write to Leeds & Northrup Company, 4973 Stenton Ave., Philadelphia 44, Pa.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · AUTOMATIC CONTROLS · TELEMETERS
HEAT-TREATING FURNACES

Which of these Corrective Chemicals is Best for Your Power Plant?

☐ **Akon**

An effective oxygen absorbent and sludge coagulant for boilers, either internally or externally treated.

☐ **Akon Bricks**

A solid composed of Akon and softening chemicals for internal treatment in low to medium pressure ranges.

☐ **Silimite**

Effective high magnesium dolomitic lime for silica reduction in connection with a hot process soda softener.

☐ **No. 20 Series**

Powdered formulations designed to control excessive scale and corrosion problems in plant cooling cycles.

☐ **No. 26 Internal Treatment**

Used as oxygen scavenger and sludge dispersive agent for boilers, either internally or externally treated.

☐ **No. 30 Series**

Powdered formulations combining all of the necessary softening chemicals with an organic dispersive material.

☐ **No. 40 Series**

Powdered formulations for scale and corrosion control as supplementary treatment for boilers in *all* pressure ranges.

☐ **No. 60 Series**

Powdered formulations for inhibiting corrosion in brine and circulating water systems and low pressure boiler plants.

☐ **No. 160 Series**

A liquid formulation of the volatile amines for corrosion control in condensate return systems.

☐ **A-C Anti-Foam**

An effective formulation to overcome damaging foaming in boilers operating over 150 psig.

Carl H. Grinnell, with 25 years experience in power plant water conditioning, is one of the Allis-Chalmers specialists located around the country to advise you on correct water conditioning equipment, chemicals and service. For free survey, call your nearby Allis-Chalmers office!

FOR OVER HALF A CENTURY, Allis-Chalmers has been building power generation equipment. This experience is invaluable in providing our water conditioning specialists with the extensive background needed today to recommend, not only the correct equipment, but chemicals and service as well.

Whatever your industry—paper, petroleum, food, steel—you'll get prompt, convincing results with Allis-Chalmers water conditioning service. An expert representative is available, ready to recommend proper chemicals or help select the right process for your power plant requirements. Get in touch with him today at your Allis-Chalmers Office for complete information.

Akon and *Silimite* are Allis-Chalmers trademarks.

ALLIS-CHALMERS

Water Conditioning

✓ EQUIPMENT ✓ CHEMICALS ✓ SERVICE

ALLIS-CHALMERS, 953A SO. 70 ST. MILWAUKEE, WIS.

Gentlemen:

Please send me specific information on the following chemicals:

_____

_____

_____

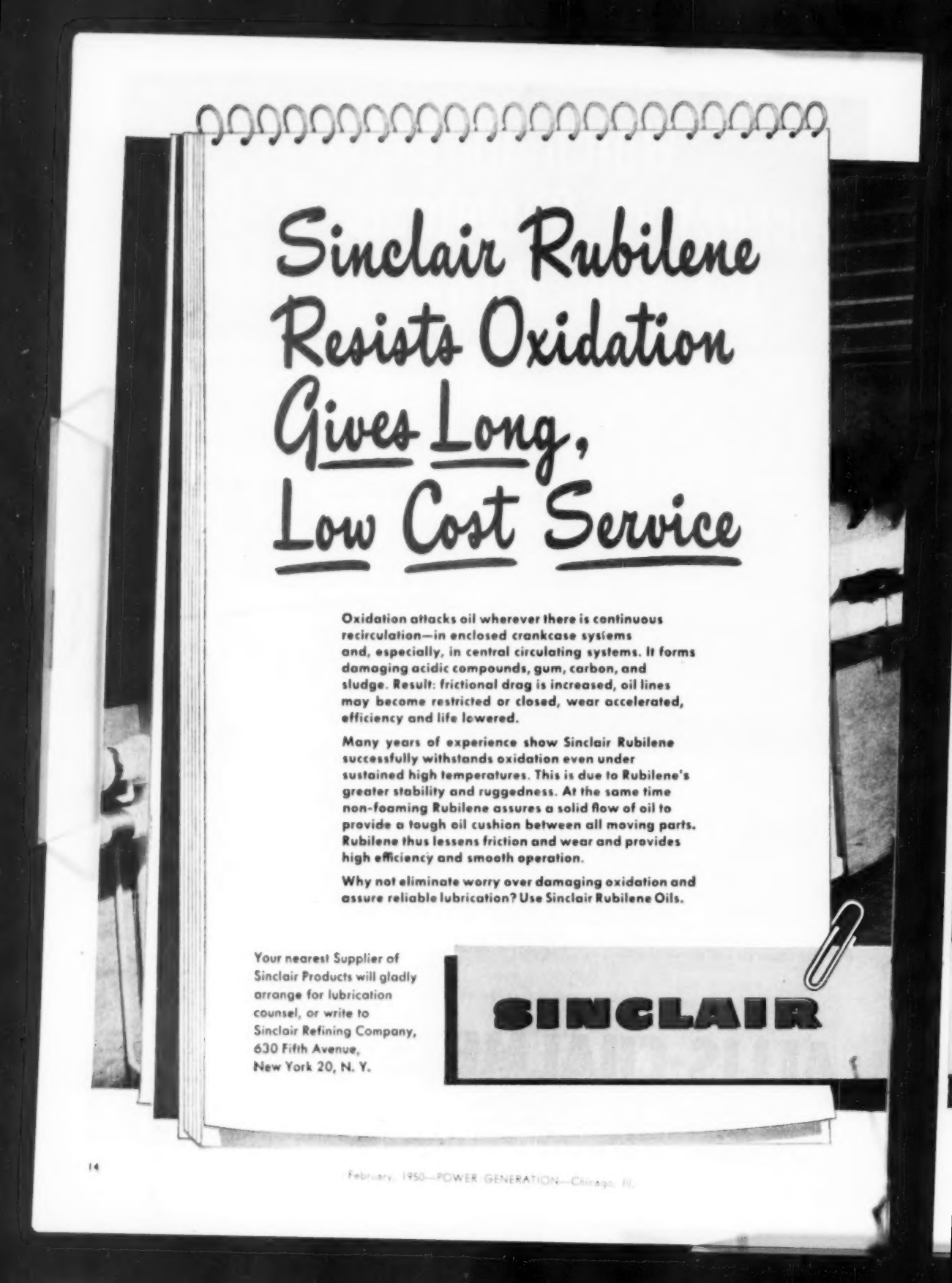
Name _____

Title _____

Company _____

Address _____

City _____ State _____ A-2910



Sinclair Rubilene Resists Oxidation Gives Long, Low Cost Service

Oxidation attacks oil wherever there is continuous recirculation—in enclosed crankcase systems and, especially, in central circulating systems. It forms damaging acidic compounds, gum, carbon, and sludge. Result: frictional drag is increased, oil lines may become restricted or closed, wear accelerated, efficiency and life lowered.

Many years of experience show Sinclair Rubilene successfully withstands oxidation even under sustained high temperatures. This is due to Rubilene's greater stability and ruggedness. At the same time non-foaming Rubilene assures a solid flow of oil to provide a tough oil cushion between all moving parts. Rubilene thus lessens friction and wear and provides high efficiency and smooth operation.

Why not eliminate worry over damaging oxidation and assure reliable lubrication? Use Sinclair Rubilene Oils.

Your nearest Supplier of Sinclair Products will gladly arrange for lubrication counsel, or write to Sinclair Refining Company, 630 Fifth Avenue, New York 20, N. Y.

SINCLAIR

Sustained New-Oil Quality
Long Oil Life
Tough Oil—Less Wear
Circulates Freely
INDUSTRIAL OILS

A.B.C. HEAVY DUTY STEAM COILS

AIRTIGHT CASING AND REMOVABLE HEATING ELEMENT

Entire heating element of American Blower Type H Heavy Duty Coil is removable from casing. Side rails provide sliding surface for easy removal and also protect tubes against damage.

REPLACEABLE CUPRO-NICKEL TUBES

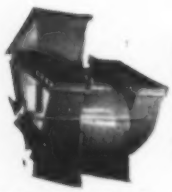
Once removed, the heating element can be completely dismantled for inspection, maintenance or repair. Individual corrosion-resistant cupro-nickel tubes are replaceable by means of heavy duty couplings.

FOR STEAM PRESSURES UP TO 350 LBS. AND 600° F.

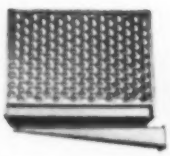
Type H Coils are available in a wide range of sizes for efficient application to any heating requirement. They are designed, tested and guaranteed for operation with steam pressures to 350 lbs. gauge and steam temperatures to 600°F.

FOR DETAILED INFORMATION ON AMERICAN BLOWER TYPE H HEAVY DUTY COILS, WRITE FOR BULLETIN B-1318 • FOR DATA ON OTHER AMERICAN BLOWER AIR HANDLING EQUIPMENT OR GYROL FLUID DRIVES PHONE OR WRITE THE NEAREST AMERICAN BLOWER BRANCH OFFICE

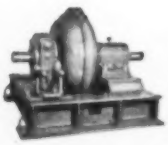
AMERICAN BLOWER CORPORATION, DETROIT 32, MICH.
CANADIAN SIROCCO COMPANY, LTD., WINDSOR, ONTARIO
Division of AMERICAN RADIATOR & Standard Sanitary CORPORATION



HS and Sirocco Fans for forced or induced draft in all types of power plants.



ST Fly Ash Precipitators—especially for power plants burning pulverized fuel.



Type VS Gyrol Fluid Drive—for adjustable speed control of mechanical draft fans.

YOUR BEST BUY

AMERICAN BLOWER

POWER PLANT EQUIPMENT

Serving home and industry

AMERICAN STANDARD • AMERICAN BLOWER • CHURCH SEATS • DETROIT LUBRICATOR • KEWANEE BOILERS • ROSS HEATER • TONAWANDA IRON

How to get a "SWEET" CONTROL JOB

There's More to Boiler Controls Than Regulators

If you want a sweet running control for your boiler plant—look to more than bare regulators when you write your specifications. Here are some additional points to consider:

Insist on controllable equipment

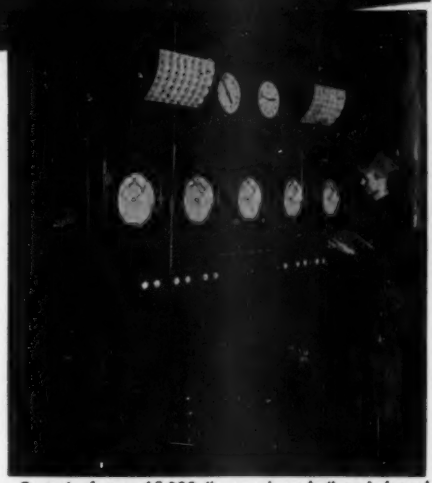
Fans, dampers, pulverizers, stokers, burners, and other equipment must be adaptable to automatic control before any system can give truly satisfactory results.

Control from all important variables

Multiple element control systems which respond to all of the important variables, insure against costly disturbances in plant operation. They increase safety, decrease auxiliary power required, and reduce the storage capacity needed in heaters and boiler drums.

Profit from the experience of others

Steam plants similar to yours already are being operated at optimum performance by Bailey Boiler Control. Your dividends, from our experience in making thousands of boiler control installations, take the form of refinements in control application which insure trouble free operation. Over 8,000 boiler units have been equipped with Bailey Controls during the past ten years. These units range from 3,000 to 1,000,000 pounds per hour capacity and operate at pressures from 75 to 2,500 psi. They are fired by pulverized coal, stokers, oil, gas, mixed fuels and waste fuels.



Control of two 65,000 lb. per hour boilers is based on the accurate measurements of these Bailey Meters at The White Motor Co., Cleveland, Ohio. Day to day evaporation runs consistently above the guarantee.

Operate control from accurate measurements

A control system is no better than the measurements to which it responds. Bailey Controls are based on accurate measurements made by Bailey Meters.

Consult Qualified Application Engineers

Bailey Engineers are qualified by training and experience to consult with you on both the theoretical and practical aspects of your boiler control problems. These specialists are conveniently located in over 30 industrial areas throughout the United States and Canada.

Details for Your Problems

If you want details write for a copy of Bulletin 15-D or ask a Bailey Engineer to call.

BAILEY METER COMPANY

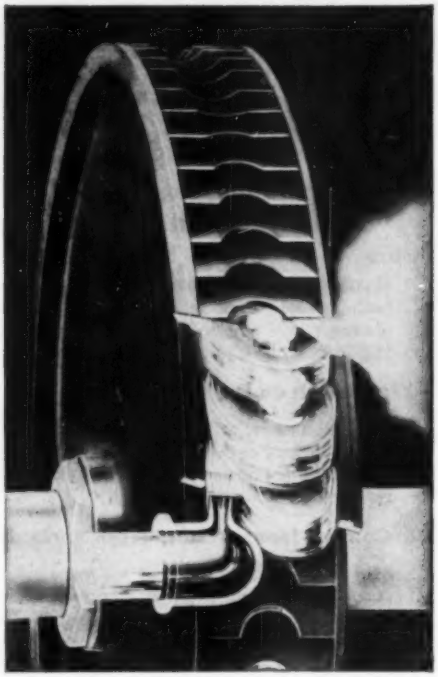
1040 IVANHOE ROAD • • • CLEVELAND 10, OHIO

Controls for Steam Plants

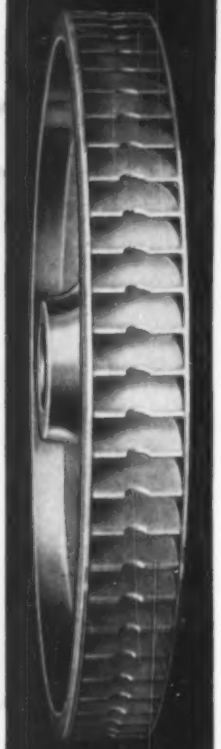
COMBUSTION • PRESSURE
FEED WATER • LIQUID LEVEL
TEMPERATURE • FEED PUMPS

A-98-1

TERRY



Action of steam in Terry wheel turbine. The steam issues from an expanding nozzle at high velocity and enters the side of the wheel bucket in which its direction is reversed 180°. As this single reversal uses but a portion of the available energy, the steam is caught in a stationary reversing chamber and returned again to the wheel. This process is repeated several times until practically all of the useful energy has been utilized.



NO PARTS TO LOOSEN OR WORK OUT

The rotor of the Terry Wheel Turbine is a single forging of special composition steel, in which a series of semi-circular buckets is milled. There are no separate parts to become loose or work out.

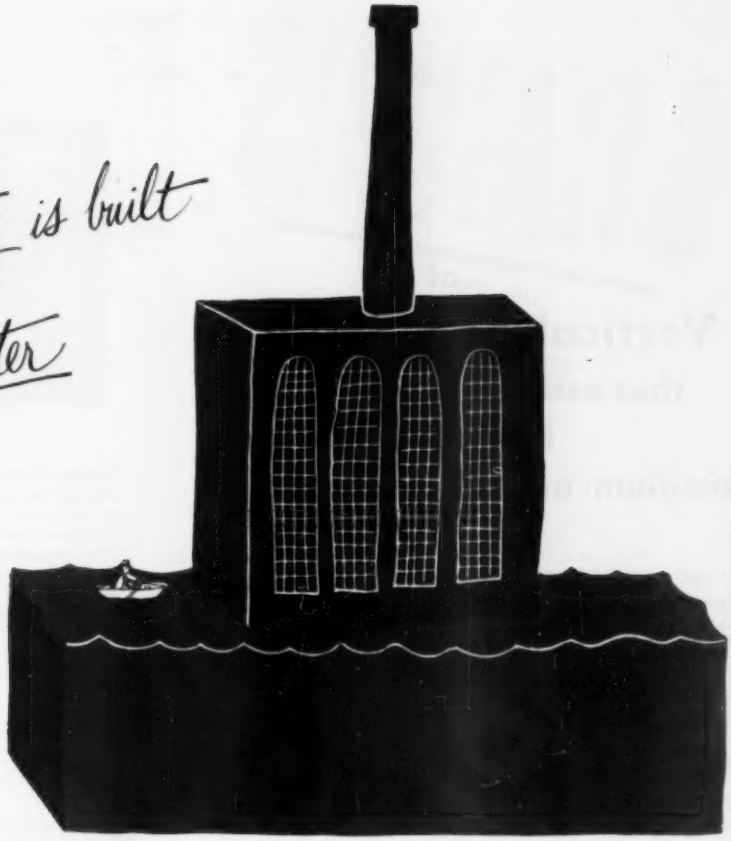
The power-producing action of the steam takes place on the solid curved backs of these buckets or pockets. Therefore close clearance is unnecessary and wear on the blades forming the pockets is of little consequence, as it does not materially affect horsepower or efficiency.

For detailed information about this effective construction and its advantages, write us on your business letterhead for a copy of Terry Turbine Bulletin S-116.

T-1172

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

Industry is built on water



WHETHER water is used only for steam generation or is required in plant process, it is today a maior industrial problem. The nature and extent of available water supplies may be a primary factor in determining the location of a new plant, or in the continued efficiency of an existing plant.

Hall engineers have solved water supply problems for hundreds of industrial plants of all types and sizes.

Sometimes the solution has been relatively simple, such as the restoration of well capacity by means of a new well cleaning method developed by Hall associates. More often, however, the problem has been a complex one involving study of the characteristics of all available waters and of the quality, quantity and temperature requirements at all water usage points.

In every case, Hall recommendations are technically sound, practical, specific and economical, showing where and how each water can be used to best advantage with minimal treatment.

Whatever your water problem may be, you will be interested in the Hall bulletin, "Water Problems neither begin nor end at the boiler." May we send you a copy?

Hall Laboratories, Inc., Hagan Building, Pittsburgh 30, Pa.

HALL *plant-wide* WATER SERVICE

INDUSTRIAL WATER TREATMENT...BOILER WATER CONDITIONING
INDUSTRIAL WASTE RECOVERY AND DISPOSAL

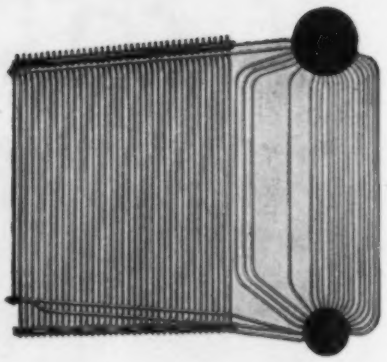
6 FEATURES of the Vertical-Unit Boiler that assure low-cost steam for medium and smaller plants

Illustrated and briefly described on these pages are the principal design features which account for the widespread popularity of C-E Vertical-Unit Boilers. Introduced originally by Combustion in 1926, this general design proved so successful that it has long since become the accepted standard for a very wide range of steam requirements.

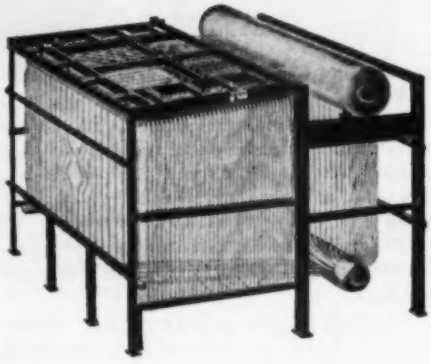
The unit shown—the VU-50—is but one of a family of such boilers developed to serve a complete range of steam needs. Unit capacities range from 10,000 to 350,000 lb of steam per hr with pressures up to 1,000 psi and total steam temperatures to 900 F, or higher. There are Vertical-Unit Boilers suitable for all methods of firing, including pulverized coal, all types of stokers and oil or gas; also for combinations of these fuels.

Compare its features item by item with those of any similar equipment on the market. They make it easy to understand why VU Units with an aggregate capacity of more than 100,000,000 lb of steam per hr have been purchased to date.

8-3218



Symmetrical Design. Any section taken through the unit from the front to rear is similar to any other section so taken. Each elemental section includes the same amount of furnace volume, the same amount of boiler heating surface and the same amount of superheater surface as any other. The volume of gases, their velocity and temperature, at any point from front to rear, are practically constant across the width of the unit.



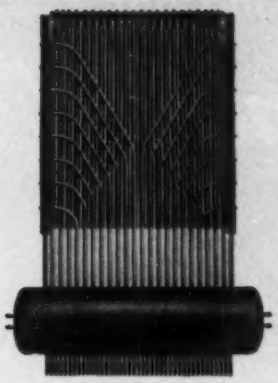
Overhead Suspension. Complete freedom of expansion in all directions is provided by suspension of all parts of the unit from the steel structure which provides the framework for the outer steel casing. This feature makes ample provision for the effects of temperature changes; it eliminates abnormal mechanical stresses on all pressure parts and explains to a large degree the freedom of the VU Unit from leaky joints.

COMBUSTION ENGINEERING—SUPERHEATER, INC.

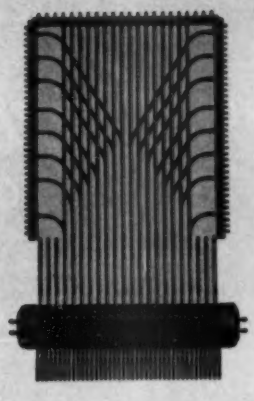
A Merger of Combustion Engineering Co., Inc. and The Superheater Co.

200 Madison Avenue · New York 16, N. Y.

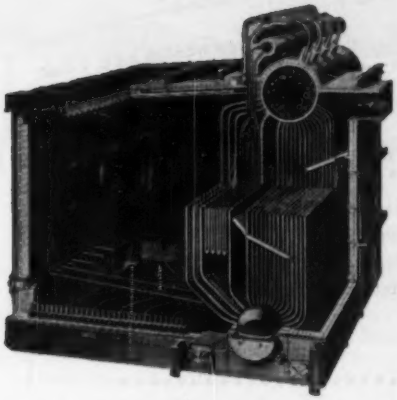
ALL TYPES OF BOILERS, FURNACES, PULVERIZED FUEL SYSTEMS AND STOKERS; ALSO SUPERHEATERS, ECONOMIZERS AND AIR HEATERS



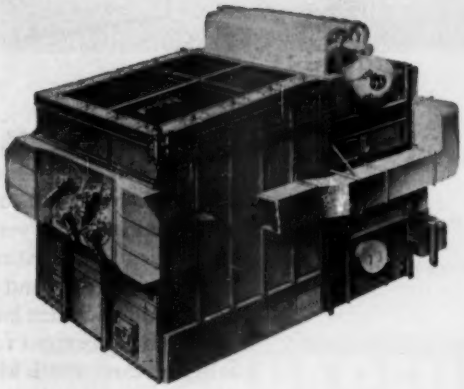
Quality Steam. All of the most active steam producing tubes enter a baffled area in the drum which discharges well above the normal water line and uniformly across the full length of the drum. This arrangement reduces turbulence to a minimum and permits effective utilization of the entire steam release space. Dry steam and a stabilized water level are thus assured even under adverse conditions.



Standardized Construction. Painstaking refinement of detail is incorporated in each unit at a small fraction of the original engineering cost. With standard parts and structural features the merits of which are confirmed by experience, manufacturing and erection costs are materially reduced. First cost reflects the economies of standardization and the buyer benefits even before the VU Unit is placed in operation.



Adaptable In Application. The VU Unit can be adapted, without sacrifice of the benefits of standardization, to a great variety of conditions: where space limitations are imposed; to burn coal, oil, gas or any combination of these fuels; to meet widely varying requirements of load, pressure and temperature. Inclusion of inter-bank or inter-tube superheater or an air heater is easily accomplished as conditions require.



Steel Encased Setting. The unit setting of shaped tile, refractory and 100% insulation are attractively finished by a permanent outer steel casing. This design, evolved from careful study and experiment, reduces to a minimum heat losses caused by radiation and air infiltration. It tends to eliminate hot spots and helps maintain a uniformly low surface temperature throughout the steel casing. Maintenance is negligible.

It's new . . . inside and out

WARREN *Cradle Mounted*

COMPACUNIT

? Do you want to handle corrosive materials that might injure the motor on a close-coupled pump?

? Do you want to use a standard or special motor or turbine?

? Do you want to use a V-Belt drive that will permit a wide range of speeds?

. . . then a Warren Cradle Mounted Compacunit could be the answer. This versatile, efficient and sturdy pump is built to "stand the gaff". . . and the price lower than you might expect for a quality product of this kind.

Sizes: 1", 1½", 2", 3"
Capacities: 5 to 450 G. P. M.
Heads: 15 to 500 feet
Materials: Standard, All Iron, All Bronze, or special to meet your requirements

Why not check this pump against your next pumping job, if within the indicated operating conditions? Ask for bulletin #242

P-21

WARREN STEAM PUMP COMPANY, INC. WARREN, MASSACHUSETTS

WARREN Compacunit PUMPS

Young turbine with a bright future . . .

•OFFICIALS of a midwest power company have every reason to believe that their new 40,000-KW turbine, shown above, will never have to be shut down for oil replacement, oil system cleaning, or because of oil acidity troubles. Their convictions are based on their own experience with Nonpareil Turbine Oil.

Since 1940, this company has put Nonpareil Turbine Oil into five big turbines, including the new unit. These five turbines have a total capacity of 188,500 KW. During the *one to nine years of operation* on Nonpareil, neutralization numbers have stayed below .06 mg. KOH/gm. There have been no time losses or troubles caused by high acidity. Oil systems have not required cleaning. Such benefits are assured this company, not only for 8 or 10 years, but for the *life* of its turbines. This assurance is based on Nonpareil's written guarantee that it will maintain a neutralization number below 0.15 mg. KOH/gm.

Why not end oil system maintenance and oil-acidity troubles, once and for all, by using Nonpareil Turbine Oil in your turbines? For more evidence of these savings, ask a Standard Oil Lubrication Engineer to supply you data from 20-year service records of Nonpareil Turbine Oil.

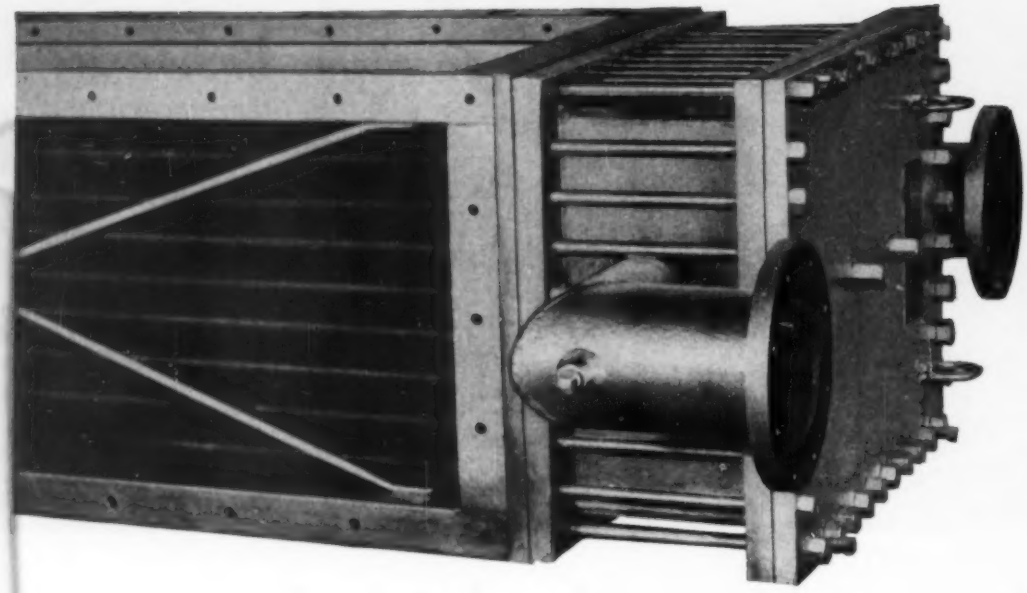
Write Standard Oil Company (Indiana), 910 South Michigan Avenue, Chicago 80, Illinois.

NONPAREIL
Turbine Oil

"Will outlast your turbine"

STANDARD OIL COMPANY (INDIANA) STANDARD

TO COOL OR HEAT AIR OR GAS ....*EFFICIENTLY*



G-R K-Fin Units are admirably suited for air and gas cooling and heating duties. The use of K-Fin Elements with mechanically bonded helical fins, requiring no tinning, enables these units to withstand high temperatures and to operate successfully on duties where loosening of fins cannot be tolerated.

One of the distinctive features of the G-R K-Fin Cooler is its cooling surface of superior effectiveness. The K-Fin elements of this unit have helical fins. These fins, forming an extended outside tube surface, provide a higher heat transfer rate for a given air or gas pressure drop than is obtainable with other finned tube coolers.

When used as a *generator air cooler*, the K-Fin unit is embodied in a self-contained, closed, dust-proof and fireproof system, using turbine condensate or other available water supply as the cooling medium.

Some of the many other applications of this unit are for recovering gases from solvents, dehydrating illuminating gas, cooling gases from annealing ovens, and other gas cooling services.

Write for Bulletin 1219 describing all the features of the K-Fin Air and Gas Cooler.

GR-238

THE GRISCOM-RUSSELL CO., 285 MADISON AVENUE, NEW YORK 17, N. Y.

GRISCOM-RUSSELL

PIONEERS IN HEAT TRANSFER APPARATUS

Link-Belt designed "Hickling" coal handling system duplicates "Jennison"

Above: Link-Belt belt conveyor handling No. 4 anthracite to bunker. Below: Jennison central station. Large illustration at top shows aerial view of Hickling.

Link-Belt integrated coal handling equipment scores again! The new Hickling central station of New York State Electric & Gas Corporation is a duplicate of a Link-Belt equipped station for the same utility, at Bainbridge, N. Y., (Jennison) which has been in operation for some years. Consulting engineers for both plants were Gilbert Associates, Inc.

Link-Belt equipment includes the following: Hopper with grating to receive anthracite from hopper-bottom cars . . . four reciprocating feeders discharging to No. 1 inclined belt conveyor . . . a reclaim hopper at the reserve storage pile with reciprocating feeder to effect uniform delivery to No. 1 inclined belt conveyor . . . bucket elevator for carrying coal from No. 1 belt conveyor to reserve storage or to No. 2 inclined belt conveyor which in turn discharges at 90° into an 18" screw conveyor serving two bunkers, each having a capacity of 350 tons.

We have designed and built a great many coal handling installations for both public utility and industrial power plants. Get in touch with our nearest office.

LINK-BELT COMPANY

Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Dallas 1, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices in Principal Cities.

11.591

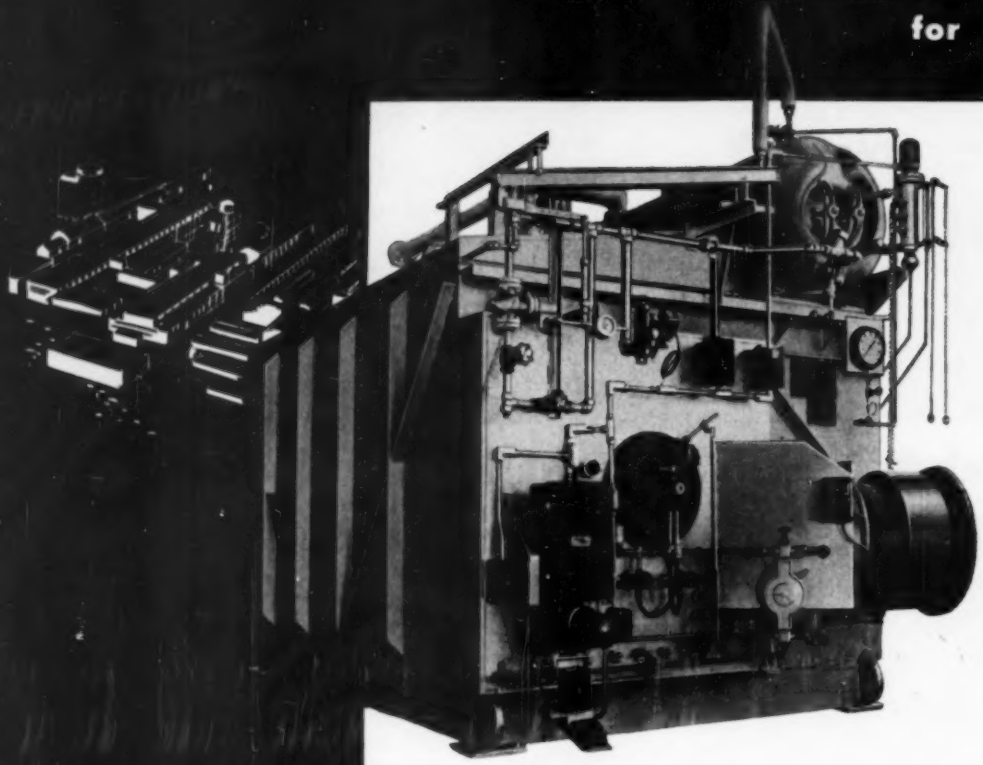
LINK-BELT

CONVEYING MACHINERY

"THE COMPLETE LINE"

Foster Wheeler Package

for



FACTORY ASSEMBLED STEAM PLANTS—Industry's need for small but efficient plants to supply power or process steam is fulfilled by Foster Wheeler *factory assembled water-tube steam generators* which can be shipped by common carrier, (truck, rail, or water) and readily installed. The labor necessary for installing a packaged unit is for the most part limited to service connections.

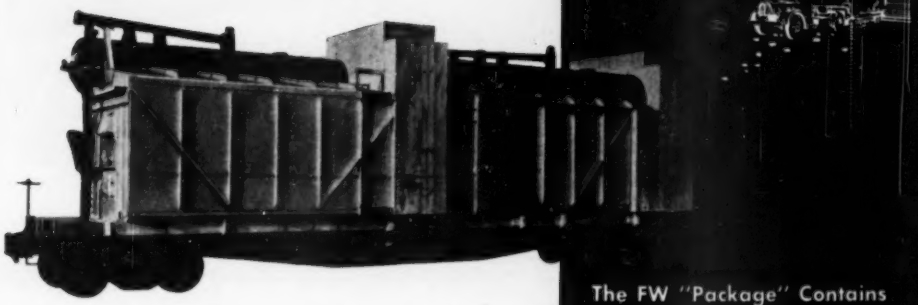
Foster Wheeler Package Steam Generators reflect the high engineering standards of an organization with over 50 years' experience in the art of steam generation and the manufacture and erection of power plant equipment. Therefore the purchaser of a Foster Wheeler Package Steam Generator is assured of skilled erection with proper assembly of any auxiliary equipment, high economy of steam production with any type of fuel, and efficient operation.

FOSTER WHEELER CORPORATION · 165 BROADWAY, NEW YORK 6, N. Y.

Assembled—Then Shipped

Units up to 35,000 lb per hr

Coal, Oil, or Gas Firing



Write for a copy of Bulletin PG-49-13e which contains drawings, sizes, and descriptions of Foster Wheeler Package Steam Generators.

The FW "Package" Contains

All These Features

Completely Factory Assembled.

Design pressures 300-500-900 psi.

Simplified water cooled furnace construction with low furnace temperatures.

Generous combustion chambers with low Btu release per cu ft of furnace volume for all types of fuel.

Positive natural circulation.

High thermal efficiency.

Choice of manual, semi-automatic or fully automatic controls.

Steel encased construction.

Drums with large volumes—manholes at both ends—factory-applied insulation.

Attractive exterior finish.

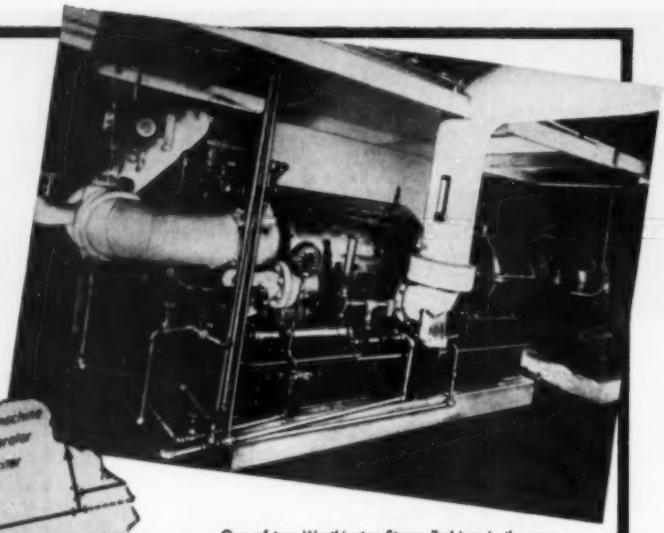
Minimum heat loss from radiation and air infiltration.

Sizes from 1500 to 35,000 lb per hr are plant assembled or field erected at customer's option.

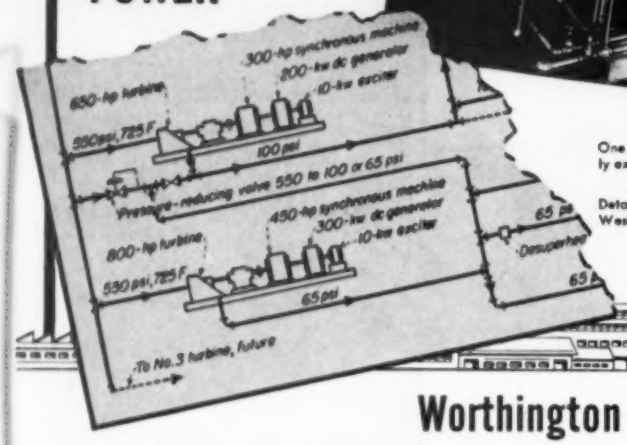
Sizes from 40,000 to 50,000 are field erected only.

FOSTER WHEELER

CANADIAN PAPER PLANT MODERNIZES WITH FLEXIBLE, ECONOMICAL POWER



One of two Worthington Steam Turbines in the newly expanded plant of the Westminster Paper Co., Ltd.



Detail from the steam-flow and pressure diagram of the Westminster plant. Worthington turbines of 650 and 800 hp, drive motor-generator sets, powering two paper machines. The smaller turbine exhausts against 100 psi; the larger against 65 psi.

Worthington Steam Turbines Chosen As Prime Movers In Novel Hook-Up

In an extensive modernization and expansion program at its plant in New Westminster, B. C., Canada, the Westminster Paper Co., Ltd. selected two Worthington Turbines as power-sources for its paper machines. (For operational data, see diagram.) Turbine speed of 4065 rpm is reduced by Worthington Reduction Gears to the motor-generator speed of 1200 rpm.

Synchronous machines, connected directly to the power system, may act as motors or generators, depending on requirements of the exhaust-steam systems — which, in turn, are controlled by backpressure governing of the turbines.

Using Worthington Steam Turbines as reducing valves, as this plant does, produces the lowest cost power of any generating system.

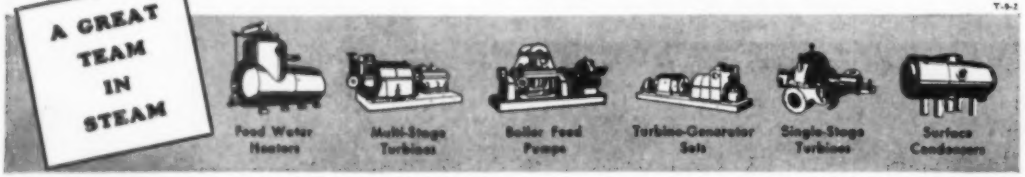
For your own power applications investigate the dependability, economy and *flexibility* of Worthington Turbines and Turbine-Generator Sets. For further proof of the *more worth in Worthington*, contact your nearest Worthington representative or district office. Or write to *Worthington Pump and Machinery Corporation, Steam Turbine Division, Wellsville, N. Y.*

WORTHINGTON

STEAM TURBINES

T-9-2

A GREAT TEAM IN STEAM



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TO INCREASE POWER OUTPUT AT NO INCREASE IN COST

THE Cities Service Industrial Heat Prover is a flue gas analyzer which quickly, accurately and completely determines the heat generating efficiency of equipment using any type of fuel. With this information necessary adjustments to increase efficiency can be made.

A complete new line of petroleum products for the power field including:

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The Heat Prover gives you the answers to these questions important to efficient production:

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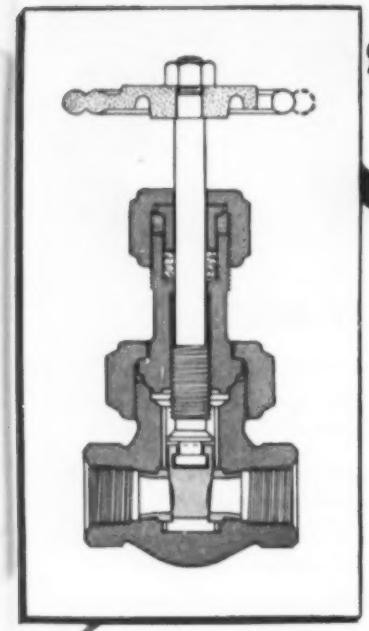
"Order VOGT Series 9850"*



Operating men everywhere rate these valves as tops for general gate valve service including meter and gauge lines, drip and drain lines, etc. Series 9850 valves have drop forged carbon steel bodies and bonnets, rolled in 11½-13% chrome stainless steel seat rings which can be easily renewed, and a solid stainless steel wedge. A ground joint insures tightness between body and bonnet. The stuffing box can be repacked under pressure when the valve is open.

Also available is Series 9750, completely fabricated from 18-8 stainless steel for services where internal or external corrosion is severe.

Series 9850-F8 valves have 18-8 stainless steel trimmings and carbon steel bodies and bonnets.

***Series 9850**

CARBON STEEL } 800 Pounds @ 750° F.
1500 Pounds Cold Non-Shock

For 150-800 pounds general service Union Bonnet • Ground Joint • Inside Screw Stem • Renewable Seat Rings • Solid Wedge — Slotted Type • 11½-13% Chrome Stainless Steel Trimmings Sizes ¼" to 2" inclusive.

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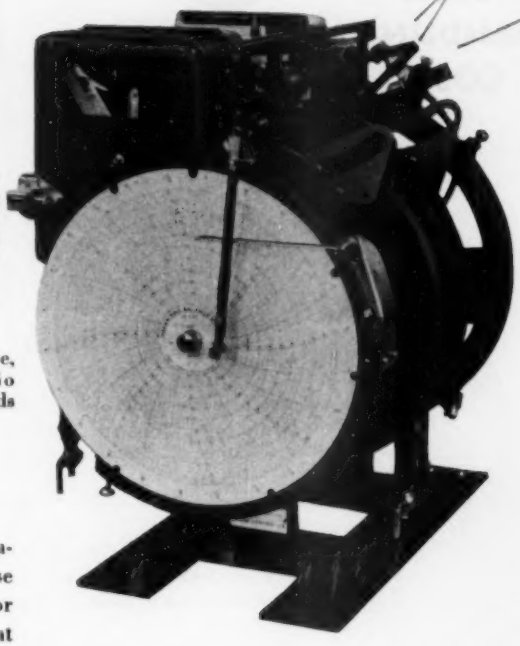

In every power plant there are applications where some of the features of these versatile meters are highly important. For full information concerning them, fill out the coupon below, or write to Hagan Corporation, Hagan Building, Pittsburgh 30, Pennsylvania.

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TO LOWER COAL HANDLING COSTS

*See How G-W does it with **Four** basic designs!*

This installation at Universal Match Corporation, Hudson, N.Y., is one of **four basic types* . . . evolved by G-W to simplify design, manufacture and erection of dependable coal storage and handling equipment. G-W engineers recommend its cylindrical steel tank type of storage because it required the least amount of space and attention . . . is clean and economical to install and maintain.

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4 BASIC WAYS TO CUT COAL HANDLING COSTS

Showing bar feeder in hopper delivering coal to screw conveyor.

*The other three G-W basic types of coal storage systems are: reinforced concrete silo, vitrified tile silo, suspended steel bunker . . . the result of over 135 years of experience in installing hundreds of coal handling systems. Why not consult a G-W engineer? He will be glad to show you how one of these four basic designs can simplify your coal handling problems . . . reduce your costs.

4

Bulletin No. 300 describes 14 case histories utilizing these 4 G-W basic types. Write for your copy today.

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Look how closely this 8-inch steam main is tucked up under the roof. And, at 410 p.s.i. and 550° F., this piping was bound to move up and down enough to need flexible support. Just the hanger to fit this situation was ready and waiting right in the Grinnell Pipe Hanger Catalog 10-D . . . the Pre-Engineered Spring Hanger fig. B268, type G.

Every pipe suspension problem is pre-solved for you by Grinnell ready-to-install hangers and supports. You can get a copy of Catalog 10-D from your Grinnell branch warehouse or local Grinnell jobber.

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HELPFUL BULLETINS

Answers to many operating and maintenance problems will be found in these new bulletins and catalogs. List paragraph numbers of those you want on coupon below, detach and mail

BOILERS AND AUXILIARIES

101 **Boiler-Stoker Combinations**—Eight-pp Bulletin SF-1 is devoted to company's combination boiler-stoker units which are factory assembled and consist of an electric-welded steel boiler and work feed stoker in steam radiation capacities up to 8,500 sq ft. Illustrated by photos of units and parts, booklet tells how units are constructed and gives instructions for installation. Complete dimensional data included. The Brownell Co.

102 **Steam Boilers**—Form SC 123-749 is a 12 pp, four-color catalog generously illustrated with photos of steam boilers for processing and heating, ranging from 15 to 500 hp and 15 to 200 psi. Includes a diagrammatic cross-section showing the four pass design characteristic of manufacturer's boilers. Stresses the advantages of these boilers. Cleaver-Brooks Co.

103 **Bent Tube Boiler Data**—This 20-pp booklet is filled with engineering drawings of recent installation of company's Class VL boilers, designed for adaptation to limited space conditions in plants having diverse steam requirements. Text covers main design features of these bent tube boilers. Henry Vogt Machine Co.

104 **Steam Generators** — Engineering data on manufacturer's coal, oil, gas or combination fired package units for generating steam up to 35,000 lb per hour is presented in Bulletin PG-49-15, 12 pp. Includes dimensional data and drawings, a discussion of design features and drawings illustrating firing arrangements. Foster Wheeler Corp.

105 **Soot Blowing Systems**—Bulletin 483 is a 16-pp well illustrated booklet describing automatic-sequential power-operated soot blowing systems. Operating procedures are discussed in detail and ten typical installations are shown diagrammatically. Stresses push-button control possible with this equipment. Vulcan Soot Blower Corp.

INSTRUMENTS AND CONTROLS

106 **Flow Meters**—Illustrated Bulletin M-51, 4 pp, explains how automatic compensation for pressure or temperature variations, or both, are achieved in flow measurement of gases or liquids with company's compensated meters. A schematic diagram shows how a corrected record is automatically and continuously produced, with the chart also showing uncorrected flow. Another diagram illustrates installation of a pressure and temperature compensated flow meter, and photos show the meters equipped for compensating functions. Hagan Corp.

107 **Liquid Level Instruments** — Illustrated Catalog 75, 24 pp, describes company's line of instruments for indicating, measuring and controling liquid level and inter-face level. Pictured and described are magnetic tape-and-drum, electronically transmitting, ball-float, pneumatic and differential pressure units; V-notch weir and Parshal flume flow meter instruments; also chemical service sight gage glasses. Fischer & Porter Co.

108 **Thermometers and Controls**—Comprehensive Catalog 110, 64 pp, covers company's line of thermometers designed for a wide range of temperature measurement applications, also special testing thermometers, gages, psychrometers and hygrometers as well as thermostatic relays and other controls, fittings and accessories. Instruments are illustrated by photos and listed with full ordering data. Book is indexed and includes price list, temperature conversion tables. The Philadelphia Thermometer Co.

109 **Shock-Resisting Meters**—A line of electrical indicating instruments which are hermetically sealed and specially built to resist shock are described and illustrated in detail in this 12-pp booklet. Discusses the meters' shock mount development, frame structure, fastening methods used, springs and other design details. Also pictures testing methods used in the development of these meters. Marion Electrical Instrument Co.

110 **Modernized Manometer** — Bulletin M-101, 4 pp, discusses recent improvements in company's reservoir-type manometer. Describes and illustrates available models, giving sizes, specifications and prices. King Engineering Corp.

112 **Leak Detector**—Bulletin CEC-1801B, 16 pp, describing company's leak detector, covers applications and leak detection methods used in both vacuum and pressure systems. Examples of probe and envelope techniques are discussed and accompanying schematic diagrams show testing equipment necessary. Operation, performance and features of the instrument are explained and accessories, parts and specifications listed. Information on service and exporting also included. Consolidated Engineering Corp.

113 **Insulation Testers**—Bulletin 21-46 presents two megger insulation testers—a rectifier operated model and a dual-operated one for either manual or separate rectifier unit operation. Gives applications for both types and illustrates principle of operation, discussing selector switch features, ohmmeter, deflecting and control cells and guard system. Full specifications included, also facsimile scales. James G. Biddle Co.

114 **Instrument Panel and Cubicle Design Data**—Modern trends in the design of knocked-down steel cubicles, cabinets, instrument panel boards, electronic enclosing cases and similar enclosures are presented by photos and engineering drawings in 12-pp Bulletin 123-5-47. Other photos show typical installations. Specifications are included and text also provides suggestions for modernization and discusses consulting services offered by company. Falstrom Co.

ELECTRICAL

115 **Progress in Power Transformers**—Information on the design of company's power transformers is presented in 24-pp Booklet B-4142. Construction details of modern shell-form and core-form oil- and air-insulated power transformers are described and illustrated. The booklet gives a brief history of transformer progress from the first American transformer patent granted to George Westinghouse in 1886 to recent achievements.

Company's "Form-Fit" construction is described and illustration of its advantages are given. Cooling is discussed at length. Problems attendant in oil preservation are discussed and protective methods shown. Auxiliary transformer equipment, such as tap changers, bushings and protective devices are covered. Westinghouse Electric Corp.

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116 **D-C Generators**—Twenty-pp Bulletin 05B7229, 20 pp, describes the construction of units larger than 150 kw or 0.3 kw per rpm, including two and three-wire generators and exciters, both engine and coupled type. It also discusses the operation of shunt wound and compound wound generators in parallel, and supplies information on company's marine units. Includes description of "frog leg" armature winding widely used on motor-generator set generators of 100 kw and larger, synchronous converters of 200 kw and larger and large low speed generators. Allis-Chalmers Mfg. Co.

117 **Standardized Control Centers** — Booklet B-4213, 28 pp, discusses the safety features of company's new control centers, including plug-in type disconnects on the line side, complete baffling of starter units for keeping possible faults localized, and design permitting compartment doors to be closed after units are removed to prevent personnel from coming in contact with live bus. Included are sections of planning a control center, a table showing dimensions and weights of starter and other interchangeable units, such as circuit breakers, single-phase distribution transformers, and lighting panelboards. Also included are reference tables for selection of starter sizes. Westinghouse Electric Corp.

118 **Dry-Type Transformers**—A versatile and flexible dry-type transformer available in a wide range of sizes for duty at the load center is described in 8-pp Bulletin 61B6362A. Also carries electrical and mechanical data on the transformers and illustrates case construction, core and coil assembly, connectors. Allis-Chalmers Mfg. Co.

119 **Glass Base Electrical Insulation**—Form EL 49-4R 1 is a buyer's guide listing names and localities of manufacturers, weavers and braiders, and distributors of Fiberglas-base electrical insulating materials. Owens-Corning Fiberglas Corp.

PUMPS, COMPRESSORS

120 **Vertical Pumps**—Eight-pp Bulletin 49-9400 describes and illustrates vertical self-priming pumps designed for fast, economical unloading and close stripping of fluids from compartments, sumps, and suitable for capacities from 600 to 4000 gpm at heads up to 500 ft. Photos and sectional drawings show pumps' design and operation, also several barge unloading installations. Provides standard specifications. Byron Jackson Co.

121 **Horizontal Duplex Compressors** — Bulletin 203, 28 pp, presents a detailed discussion covering the design and operation of gas or air compressors of the water-cooled type for heavy duty service, stressing principle of control for five-step regulation. Also covers starting, power consumption, automatic protection, lubrication and methods of drive. Text is illustrated with photos of compressors and component parts, sectional drawings, installation pictures. Pennsylvania Pump & Compressor Co.

WATER CONDITIONING

122 **Water Softener**—Bulletin W-212-B5 introduces a cold process slurry type precipitating water softener and coagulator using hydraulic energy for mixing applied chemicals with previously formed precipitate. This 16-pp bulletin is illustrated by photos, cutaway drawings and large flow diagram. It explains operation of the unit, describing in detail the vortexor, proportioning meter, control panels and other parts. Also includes a general discussion of precipitating systems, old and new. Worthington Pump and Machinery Corp.

123 **Scale Prevention**—Here is a general discussion of the various causes of scale formation and preventive measures to be taken. Illustrated by photos of scale deposits. Includes list of typical applications for company's products covering their use in boiler water conditioning, steam and condensate systems, hot water systems and others. Wright Chemical Corp.

LUBRICATION

124 **Turbine Lubrication**—The problems of oxidation, emulsification, foaming and sludging, as related to turbine lubrication, are discussed in this 4-pp illustrated maintenance folder, No. 2-477. Includes discussion of proper flushing of turbine systems and features of company's fortified turbine oil. Also briefly describes some of company's other lubricants and related products. E. F. Houghton & Co.

125 **Lubricating Oil Coolers**—Eight-pp Catalog 31, compiled for "engineers with a lube oil cooling problem," contains data covering construction details, selection, heat transfer rate, capacities and pressure drop. Illustrated with blue-print type drawings and photos of manufacturer's lubricating oil coolers. Condenser Service & Engineering Co., Inc.

VALVES

126 **Automatic Valve Specialties**—Company's line of pressure, flow, and liquid level controls for steam, air, gas water, oil and other fluids is presented in 60-pp Condensed Catalog A-50. All equipment is described as to construction and application and illustrated by photo or sectional drawing. Dimensions and prices are included. Technical data includes capacity charts and conversion tables. Davis Regulator Co.

127 **Diaphragm Control Valves**—Dimensions, specifications, and operating data on manufacturer's "on-off" air-operated diaphragm control valves is presented in 4-pp Bulletin 350-1. Illustrated with photo of valve and sectional sketches showing direct and reverse acting types; single seat, double seated, and three-way types. Beifield Valve Div., Minneapolis-Honeywell Regulator Co.

MISCELLANEOUS

128 **Pipe Tool Ordering Guide**—Catalog 50, 36 pp, is company's recently revised ordering book covering the entire line of pipe tools, machines, power drives and threading oil. Products are illustrated by photos, some in color, and operational advantages are fully explained in the text. Ordering specifications are concise and clear. Catalog includes current price list, also names of prominent users of these tools. Beaver Pipe Tools, Inc.

129 **Steam Separators**—Bulletin S-14-C, 12 pp, presents line of separators for removing unwanted elements from steam, air and other vapors. It is profusely illustrated with photos, diagrams and line drawings, gives full specifications, selection and ordering data on company's helico-centrifugal separators of both vertical and horizontal types. The Swartwout Co.

130 **Sound Powered Phones**—The operating principle, special features and use of sound powered telephone equipment especially developed for mines, industries, public utilities, is discussed and illustrated by photos in illustrated Catalog 400-A, 8 pp. Stations and systems, handset and headset instruments are described and pictures. Wiring data and diagrams are provided, also specifications. United States Instrument Corp.

131 **Transmission Belting**—Catalog Section 2100, 4 pp, on rubber transmission belting covers several types, all of which are pictured and described along with recommendations for use and specifications. Also outlined in detail and illustrated is the method of making belts endless by the "Flylock" belt joint. The B. F. Goodrich Co.

132 **Diesels for Stationary Duty**—Diesel engines for stationary installations are described and illustrated in 20-pp Bulletin 4812. Touching briefly on company's 60-year history in engine research and production development, the book presents numerous recent installations of these engines in municipal, public utility and industrial power plants. Includes more than 100 engine specifications ranging in power from a naturally aspirated, six-cylinder 175 hp engine to a supercharged eight-cylinder 1500 hp engine. Superior Engine Div., The National Supply Co.

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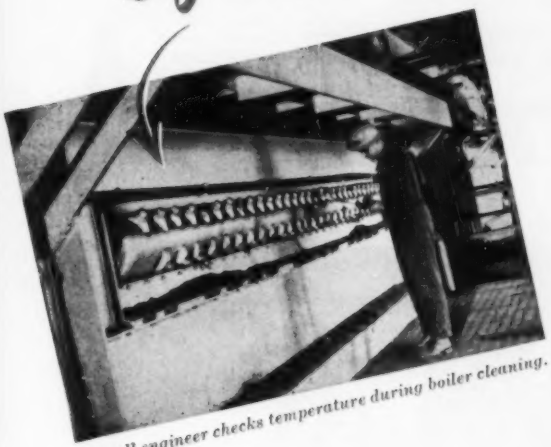

Dowell engineer checks temperature during boiler cleaning.

Quick, Effective Maintenance Service Cuts Total Down Time in Half

A TYPICAL EXAMPLE of the economies afforded by Dowell Service is reported in the case of a midwestern refinery using five 300,000 lb. per hour boilers to generate electrical power. Before Dowell Service was used in the plant, boilers were usually down two weeks whenever repairs became necessary—during which time electricity was purchased from an outside source. Using Dowell Service to do the internal surface cleaning, the boiler is back in use in one week instead of the usual two! And the Dowell part of the operation takes just one day!

Dowell Service, using the experience of thousands of successful jobs, offers you the solution to maintenance problems of this type. It is backed by strong, continuous research programs, both in Dowell's own laboratories and in those of The Dow Chemical Company. This research provides the means for an improving service with an increasing degree of effectiveness and safety.

When you call on Dowell Service for your maintenance cleaning, experienced Dowell engineers do the job for you. They bring the special equipment—truck-mounted tanks, mixers, heaters, and proportioners—necessary for controlled cleaning. No dismantling or scaffolding is required. Liquid solvents are pumped into the equipment through regular connections. Down time is held to a minimum.

For quick, practical, economical cleaning of boilers, heat exchange equipment, water lines and water wells, call the nearest Dowell office. Free cost estimates gladly given.

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Tough Assignment, too!

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non-return VALVES

In thousands of tough applications Golden-Anderson Non-Return Valves are protecting life and property by automatically performing these three vital functions:

(1) Cut in boiler when pressure equals line-header pressure.

(2) Isolate boiler when pressure is lower than line-header pressure.

(3) Prevent steam flow from boiler in event of sudden line-header pressure drop.

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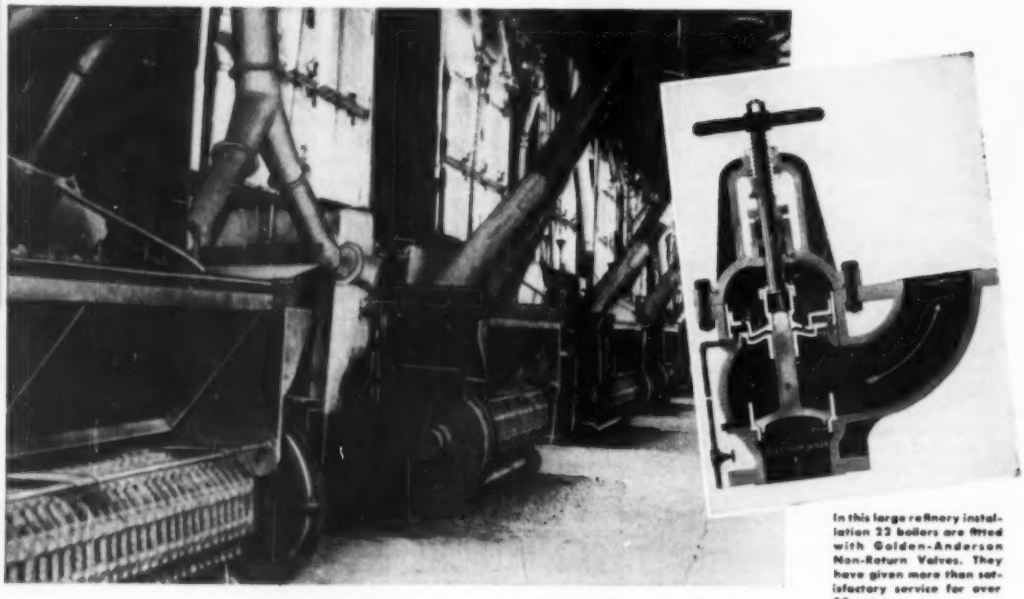
VALVES SINCE 1903

"Double Corliss" dashpot assembly prevents banging, chatter or spinning under any flow conditions. Write for technical catalog today.



In this large refinery installation 22 boilers are fitted with Golden-Anderson Non-Return Valves. They have given more than satisfactory service for over 35 years.

GA **GOLDEN-ANDERSON** *Valve* Specialty Co.

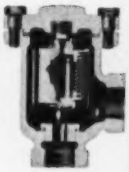
KEENAN BUILDING, Pittsburgh 22, Pa.

How to be Right the first time

WHEN SELECTING STEAM TRAPS

No single type of trap is suitable for all applications. But one of the four distinct Sarco types will be exactly right for any given application. Some provide quicker warm ups in the morning, some extract more of the heat, some are better for fluctuating condensate loads and others are better for out of doors. Sarco has the only plant devoted exclusively to complete lines of steam traps and temperature controls. To be sure, the first time, see Sarco first.

A THERMOSTATIC



Wide open when cold for quick starts. Retains more of the heat before releasing condensate. Large valve orifice purges air quickly when starting. No seat changes when pressures change. Cannot freeze. Two types—for low pressure heating and high pressure industrial service up to 300 psi. Bulletin No. 250.

B FLOAT

Ball float allows continuous discharge without shock to temperature controls and other instruments. Automatic thermostatic by-pass takes care of air and gases without steam waste. All pressures up to 200 psi. Bulletin No. 450.

C BUCKET

Intermittent, but very rapid—can handle large volumes of condensate. Air goes out with the condensate. All parts attached to cover provide easy inspection. Straight-through connection makes installation easy. Integral strainer inside. Standard sizes to 250 psi. Forged steel types to 900 psi, and superheat. Bulletin No. 350.

D LIQUID EXPANSION

A low cost combination of trapping and approximate temperature control. Ideal for outdoor tanks and lines and other points where condensate cannot be returned. In other forms, used as combination trap and control for wash tanks, food equipment, etc. Catalog Nos. 250 and 550.

APPLICATION	1st CHOICE	2nd CHOICE
Process Tanks, small	A	C
Process Tanks, large	B	C
Dryers, Coil Type	B	A
Dryers, Fan Type	B	C
Drying Tumblers	B	A
Water Heaters	B	C
Preheaters, Fuel Oil	B	C
Rotating Cylinders	B	B
Slashers	B	B
Dry Cans	B	B
Flat Work Ironers	C	B
Presses, Laundry	C	A
Stocking Forms	C	A
Presses, Plastics	C	A
Presses, Platen	C	A
Evaporators	B	C
Steam Lines Outdoors, small	A	D

Ask for Bulletin No. 1600 "Selecting Steam Traps"

347

SARCO SAVES STEAM

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Speeding express trains and thundering freights can cause serious vibrations with damaging effects on equipment located nearby. Here's a C. H. W. water cooling tower installed so close to one of the country's heaviest traveled railroads that passing trains nearly knock your hat off. This tower of The Bayer Company, aspirin manufacturers at Trenton, N. J., is as good as the day it was built. And there are many good reasons why they haven't had any "headaches" with it. In a C. H. W. cooling tower you get a sturdy structure, assembled by experts, with redwood members rugged enough to withstand stresses, strains and vibrations (caused by trains or most anything else up to hurricane winds of 100 m. p. h.). Wood fill is of sufficient size and weight to "stay put" without the use of nails, and vertical members are securely bolted. A distorted distribution system or wood fill "out of place" affects the efficiency of the tower—hence the reason for C. H. W.'s "vibration proof," rugged construction. For other exclusive features of C. H. W. towers, write for literature.

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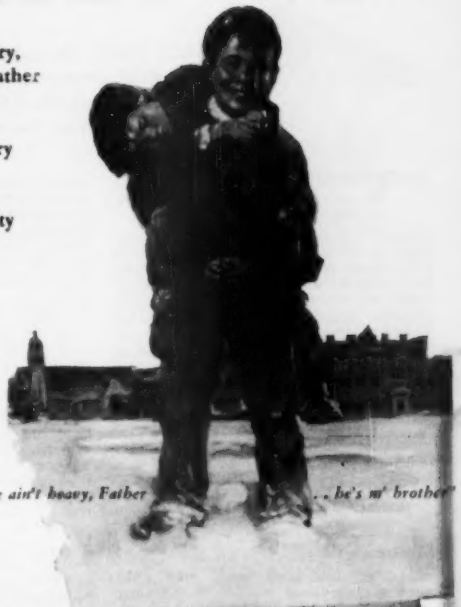
STEAM CONDENSERS - WATER COOLING TOWERS
EJECTORS - STEAM JET VACUUM REFRIGERATION
OF PHILADELPHIA

For a Bigger BOYS' TOWN

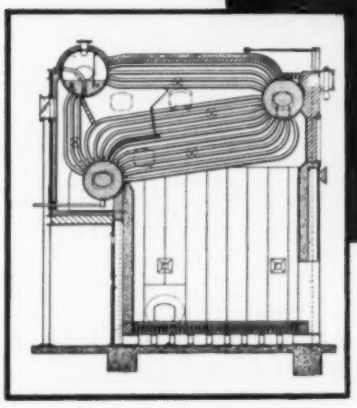
550 more deserving boys . . . meant more housing, more laundry, more heating, more food . . . all calling for much more steam at Father Flanagan's Boys' Town near Omaha, Nebraska. From a model new boiler plant, all steam required to accommodate 1,000 youthful citizens at work and play is being supplied by a battery of four Type H Stirling units. Selection of these boilers by such a famous charitable institution, where every operating dollar is a trust, indicates confidence in their outstanding ability to deliver dependable, clean, dry, low-cost steam for many years of trouble-free service.

Perhaps *your* steam requirements fall within the highly-efficient, economical range of the Type H Stirling Boiler. Find out why more than 2,000 units of this type are now serving industrial plants, smaller central stations, laundries, office buildings, institutions, hospitals, schools, and other industrial and non-industrial users. Write for Bulletin G-8-E. The Babcock & Wilcox Co., 85 Liberty St., New York 6, N. Y.



"He ain't heavy, Father . . . he's m' brother"

Type H Stirling Boilers, each of 17,600 lb. per hour steam capacity, oil- and gas-fired.



BABCOCK & WILCOX

G-447

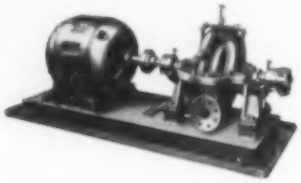
NEW EQUIPMENT NEWS

WHAT'S NEW? On these pages the Editors summarize the outstanding industrial developments of leading manufacturers who will supply you, free of charge, the bulletins or other information desired. For ease in making requests use the no-obligation, postage-paid card pages 35-36.

1—CENTRIFUGAL PUMP

Is two-stage, hydraulically balanced, volute type with steel shaft

Available in capacities to 825 gpm, total head to 800 ft, these pumps are said to offer long service, efficient operation and reduced maintenance. Design features emphasized include water cooled, duplex, angular contact ball thrust bearing; labyrinth seal; heavy, horizontally split casing with flanged bearing



supports; interstage seal, and only suction pressure on stuffing boxes. Cast iron with bronze fittings is standard, but all cast iron or all bronze models are available; special metals may be ordered. Warren Steam Pump Co., Inc.

2—TEMPERATURE INDICATORS

Thermocouple and resistance types for a wide range of applications

Included in this line are cold-end compensated thermocouple thermometers for measuring temperatures up to 3000 F and resistance thermometers for temperatures up to 300 F. The former are available in two sizes: the Type DO-71 with a 3½-in. flange and the DW-71 with a 2½-in. flange. Both types can be supplied in square or round molded Textolite cases.

Designed for the measurement of low temperatures where high accuracy is important, the resistance thermometers are available in two standard types: the DB-15 long-scale instruments and the Types DD-6 and DD-7 6-in. rectangular, surface- and flush-mounted instruments. These thermometers are

suitable for such jobs as bearing temperature measurement, generator- and transformer-winding temperature indication, refrigeration and air conditioning testing, and remote fluid temperature indication. Meter and Instrument Divs., General Electric Co.

3—BELT PRESERVATIVE

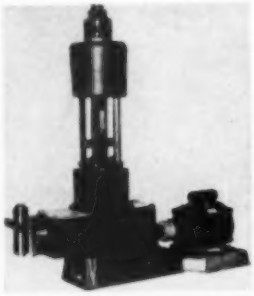
For economical slack-belt operation, comes in applicator can

The No. 50 Preservative is intended to keep belts from slipping and permit easy or slack belt operation. Applicator can makes it easy to use and permits keeping preservative near points of application, company points out, adding that regular applications keep belts pliable and add to their service life. Treated belts are also said to require fewer "take-ups," and deliver more power. Preservative comes in quart or pint applicator cans, 12 or 24 to a carton. A working sample is available to qualified power engineers who ask for it. Cling Surface Co.

4—PNEUMATIC ACCESSORY

For automatic control of output of proportioning pumps

Available for use with all models of company's Pulsafeeder line of pumps is the Auto-Pneu-Matic Control System, suitable for use with commercial pneumatic systems. An important feature of the Pulsafeeder design is the ability to



adjust output while in operation, company explains, but manual control of output requires operation of a handwheel. With the pneumatic control, however, it is said that automatic volume change from zero displacement to full displacement is provided, automatic and in responce to instrument air pressure change.

The new accessory is said to make possible systems in which pump output is made responsive to any measurable variable, such as flow pH, temperature change, liquid level, pressure. Process Equipment Div., Lapp Insulator Co., Inc.

5—ELECTRIC CAPSTAN

For car pulling, barge moving jobs and built for one-man operation

Besides pulling and spotting cars, this capstan is recommended for towing trucks, bending pipe, dragging logs and

moving skid loads. According to manufacturer, it can be used on the level, up grades and inclines, and around corners and curves.

Alloy steel capstan barrel is only moving part exposed. Gearing is integral with motor and functions as one unit. Motor is squirrel cage hoist type available in 7½ hp for starting pull of 6000 lb, and 15 hp for starting pull of 12,000 lb. Entire gear mechanism is enclosed. Silent Hoist & Crane Co., Inc.

6—PROTECTIVE COATING

For weather-exposed service at temperatures up to 750 F

Silicone Coating Aluminum is said to utilize high heat resistance and water repellency and low moisture absorption of silicone resins, this coating is formulated to withstand continuous exposure to heat or intermittent heating and chilling as well as chemical fume attack. It is described as suited for outdoor service in industrially contaminated atmospheres as well as chemical-fume attack. It is recommended for use on stacks, furnaces, boilers, heaters, steam lines, gas burners, exhaust mufflers.

Its fluid consistency permits application by brush or spray to any reasonably well prepared iron, steel, galvanized or other metal surface, company states, whether new or previously in service. Recommended coverage is 1000 sq ft per gal, and drying time is ½ to 3 hr. The Dampney Co. of America.

USE THE NO-OBLIGATION, POSTAGE-PAID CARD ON PAGES 35-36

Piping equipment for every system... from one complete line

FOR BETTER CONTROL OF HARD-TO-HOLD FLUIDS

Crane Diaphragm Valves—in plain iron or Neoprene-lined types—are ideal for conveying compressed air, compressed or liquefied gases, volatile and corrosive fluids. Crane separate disc-diaphragm construction—a revolutionary improvement in packless valve design—makes these new valves safer, more durable, more efficient.

On Crane valves, the diaphragm is used only to seal the bonnet . . . is not subject to cutting, crushing and rapid wear. A separate circular disc permits positive shut-off even should the diaphragm fail. Y-pattern body design assures greater flow capacity, minimizes pressure drop. Crane separate disc-diaphragm design reduces appfeciably the torque required to operate these valves. For further information, WRITE FOR CIRCULAR AD-1761.

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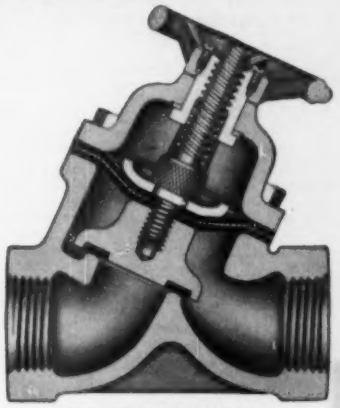

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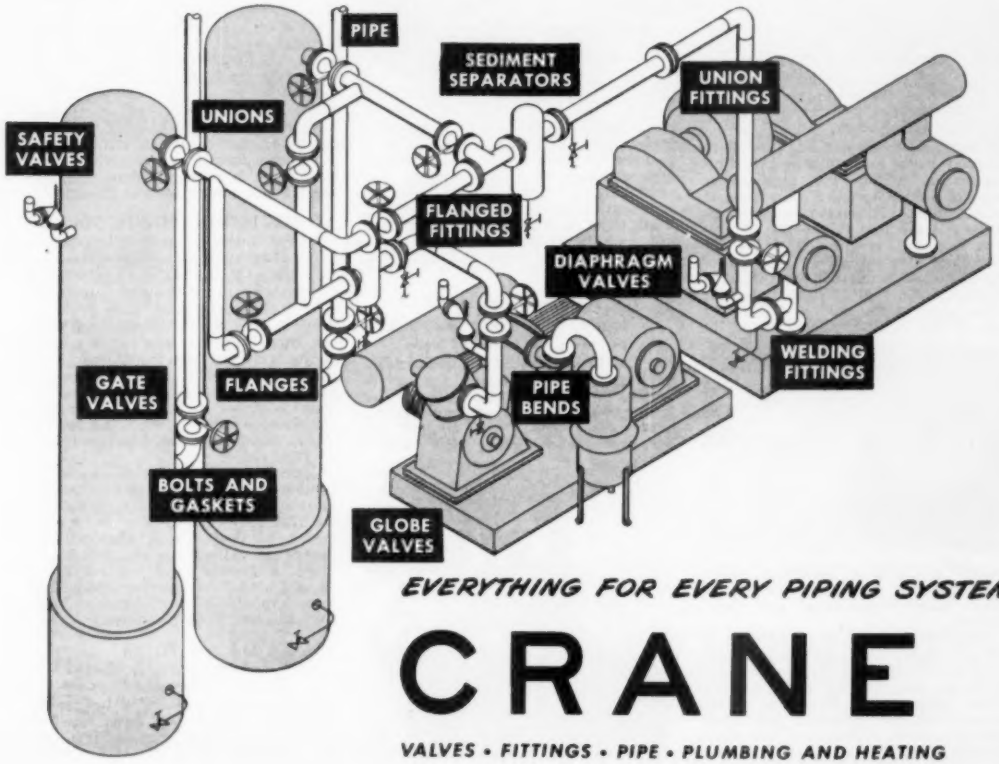

EVERYTHING FOR EVERY PIPING SYSTEM

CRANE

VALVES • FITTINGS • PIPE • PLUMBING AND HEATING

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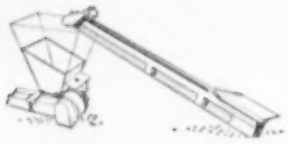
7—COAL CONVEYOR

For filling of overhead hoppers on spreader stokers, in two capacities

Although especially suited for overhead hoppers, the Hi-Hopper Conveyor is also recommended for underfeed hoppers where capacity has been increased by extending the sides, to simplify hopper filling and extend the period of stoker operation without attention. This conveyor is also suggested for use as a flat conveyor or for trimming bins.

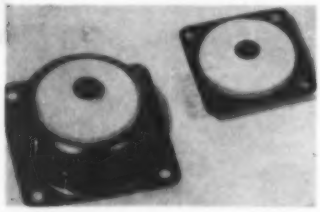


Of all-welded steel construction, the Hi-Hopper is made in two standard models, but custom-built conveyors are available. Model MM4 has a 4 in. belt and 25 t per hour capacity, weighing only 135 lb in the 12 ft length. It can be supplied with undercarriage for portable installation. Model MM8 has 8 in. belt, and 60 t per hour capacity and is recommended for permanent installation where large tonnage is involved. Prices begin at $195. New London Engineering Co.

8—SILICONE RUBBER MOUNTS

For vibration dampening at extreme high and low temperatures

Cohrlastic Mountings will carry their designed loads and absorb disturbing frequencies within the temperature range of -100 F to 500 F, according to manufacturer. Their temperature resistance is credited to the use of silicone rubber, engineered into the mountings to give loading and deflection as called for in AN specifications. Mountings are said to protect delicate instruments in the cold of the Arctic and of the sub-stratosphere—and be



equally effective in locations where high ambient temperatures would make many mountings soft and gummy.

They are available in many sizes of the AN instrument series and company points out that these mountings could be designed for most services where temperature resistance is required with the vibration characteristics of a shear type mount. The Connecticut Hard Rubber Co.

9—LIQUID ALGAECIDE

Forms emulsion in water, for use in open or closed boiler systems

Poly-Cide is described as non-corrosive, non-scale forming and non-toxic. The stability of the emulsion formed with water is said to make it adaptable to closed systems—small, infrequent "booster" shots being all that is required to maintain a clean system. Open systems are treated in a similar manner, company adds, and in treating once through systems one or two injections per day prevent algae deposits. It is also stated that a 5 per cent emulsion in water forms an effective deodorant and germicidal rinse for washrooms. Poly-Cide comes in 5, 15, 30 and 55 gal containers. The Brooks Boiler Treatment Co.

10—INSULATION TESTER

Is engineered for either hand crank or rectifier operation

This megger consists of the "meg" type constant-pressure test set and a separate rectifier which supplies 500 v d-c from any 115 v, a-c, 60 cycle outlet. One cord from the hand-crank instrument and other from the rectifier to an a-c outlet eliminates hand operation, company explains.

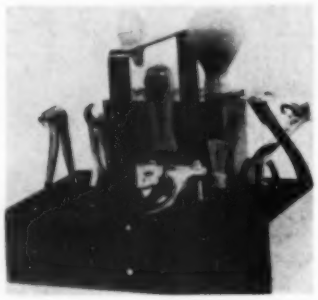
This dual-operated instrument is expected to have its most important application in extensive cable wiring and control installations where an a-c out-

let is readily available. It is believed to be especially valuable where continuous operation of the instrument is desired. According to company, the availability of the hand cranked instrument, without the rectifier, makes it attractive to traveling inspectors and test men in power work and others who would use it in the field. James G. Biddle Co.

11—BATTERY SERVICE KIT

Has steel tray with handle and compartments for tools and water

The handy GS No. 3F Kit is intended for keeping all tools needed for servicing batteries in one place. The water jar provided is made of long-wearing hard rubber with a hole to hold the hydrometer and another for a battery



filler. A space is provided for a cell tester to prevent breakage. Water jar won't tip over, company points out.

Other compartments are spaced to hold battery terminal spreader, plier, carrier, brush and terminal puller. Complete with eight tools, the kit costs $20.50—kit without tools costs $7.90. General Scientific Equipment Co.

12—CAPACITOR MOTOR

For use wherever power supply demands single-phase operation

Of cast-iron construction, the integral horsepower Tri-Clad Motor presents a streamlined appearance. Capacitors are mounted in the base, and instead of a conduit box on the side there's a built-in terminal board inside the end shield.

This motor weighs 15 to 20 per cent less than former model, manufacturer reports, and it has an enclosed built-in starting switch and new centrifugal mechanism designed for long service.

In ratings from ½ to 5 hp, these high torque motors are available in Type KCS, capacitor start, and Type KCR, capacitor run. According to company these differ only in starting current. The Type KCS is designed for 115/230 v, while the Type KCR is a single voltage, 230 v design. Motors have lubricated ball bearings intended to run for years without relubrication, but grease fittings are accessible when lubrication is needed. Small and Medium Motor Divs., General Electric Co.

13—ELECTRONIC POWER SUPPLY

Is developed for fault location in power and communication cable

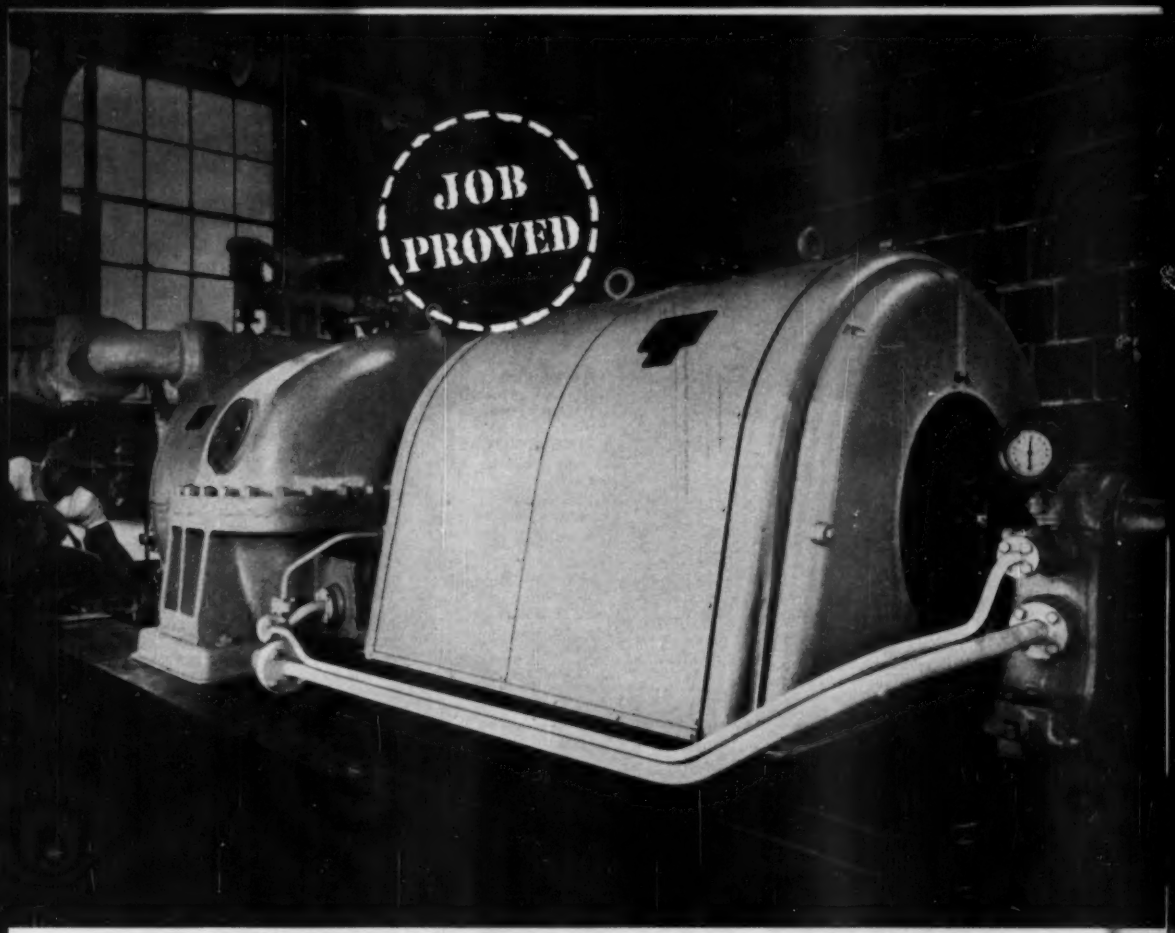
The Telemetron has been developed for use with the Telemetroscope (pulse type fault locator) to locate high resistance cable faults. Using high voltage, this equipment establishes a spark at the fault and then maintains an arc through the use of lower voltage and constant current. Because of low impedance of the arc, the Telemetroscope can then be used to locate the fault as it would any other low resistant ground or short.

Operating from the sub-station, the trouble shooter is said to locate any fault within a few minutes. Additional features emphasized for it include means for hi-pot test, capacitor discharge across ball gap for fault breakdown, and constant direct current of 10 amp. Available in d-c voltage ratings: 0 to 50,000, 0 to 25,000, 0 to 10,000, 1000 and 500. Tobe Deutschmann Corp.

14—OIL OR AIR FILTER

Is designed to provide effective filtering area within minimum space

This filter is recommended for removing solids down to 1 or 2 microns from liquids, for separating water from fuel oils, gasoline. May be used as a gaso-



CORROSION THREAT ENDED BY SUNVIS 916

Turbine Under Intermittent Operation Gets Year 'Round Protection

A utility company serving an island summer resort operates an auxiliary turbine at peak capacity throughout the vacation season. But for the rest of the year, this equipment is shut down and corrosion is a constant threat. An oil is required that will keep the equipment running under the heavy summer load, and maintain it ready for instant use in case an emergency should arise during the off season.

More than two years ago, acting on the advice of a Sun engineer who had been consulted, the company filled the circulating system of its turbine with Sunvis 916 Oil. The unit is still running on the original charge and inspection shows complete absence of corrosion.

There has been no perceptible wear of parts. The Sunvis 916 Oil is in excellent condition and only slight make-up has been required to take care of normal leakage.

This is but one of many examples of how "Job Proved" Sunvis 900 Series Oils protect vital and expensive machinery. They are highest-quality, solvent-refined oils, specially manufactured to resist oxidation and sludging, and to protect metal parts against rusting and corrosion. For a copy of the illustrated booklet "Sunvis 900 Oils," write Department PN-2.

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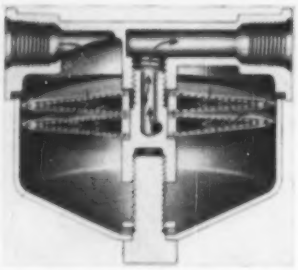


line filter for gasoline engines, fuel oil filter for Diesel and jet engines and oil burners, and air filter for compressors, engines, and compressed air lines.

Among features emphasized for the filter is the method by which its series of V-shaped horizontal filter discs are bolted into the cover of the housing to make them easily removable for cleaning or replacing. Each disc consists of two perforated leaves separated at the center by a perforated flange, and covered with various filter media to provide a wide range of porosity and degree of filtration. Housing is high pressure cast aluminum and contact parts are rust proofed, company states, adding that filter comes in sizes and capacities to meet all requirements. Sparkler Mfg. Co.

15—UNDERFEED OILERS

For lubricating bearings and shafts requiring a small amount of oil

This oiler is mounted at the bottom of the bearing. One end of the solid felt wick is held in contact with the shaft by positive spring action. The other end rests at the bottom of the oil reservoir. Oil is raised by capillary action to the tip of the wick where it is distributed along the shaft. Oiler stops

feeding when machine is not in motion.

A clear, shatterproof plastic bottle is provided to keep oil supply visible. Metal parts are heavily plated for corrosion resistance and easy cleaning. Heavy steel base is cemented and roll-clinched to plastic reservoir. Oiler is said to be easily installed; available in 1, 2 and 4 oz capacities. Trico Fuse Mfg. Co.

16—ELECTRONIC TRACER

For locating defective point in wire, metal pipe, other conductors

No technical knowledge is required to operate the Electracer, its manufacturer states, pointing out that it locates grounds, shorts, open circuits, radio interference, wiring, conduit or piping in Diesel engines, electronic equipment, communications equipment and industrial machinery.

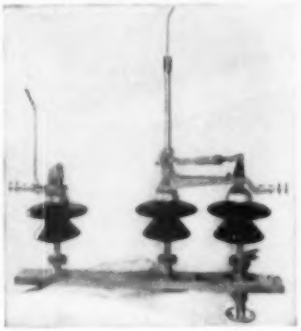
Consisting of a signal generator, portable probe, receiver and headphones, the Electracer is designed to operate by signal generation. The signal generator follows a conductor, company explains, that may be imbedded in a wall, buried underground or lost in a maze of other pipes and wire. The generated signal is followed with the probe, amplified by the receiver, and heard in the headphones so the route of the conductor, point of defect or end of conductor can be quickly determined. List price of instrument is $96.50. Special Products Co.

17—DISCONNECTING SWITCHES

Are braidless type, rated for 7.5 to 69 kv outdoor service

The new type RF switches are a rating extension of company's high-voltage (115, 116, and 230 kv) units previously available. They feature silver-to-silver line pressure contacts, a simplified operating mechanism, and elimination of current-carrying braids.

On the hinge end of the switch, the



silver surface of the movable blade engages the silver surface of a U-shaped clip backed by adjustable stainless steel compression springs. This is intended to assure a positive contact at all times during opening and closing operations, and prevent burning of switch. Clip contacts also are braidless and have silver-to-silver line-pressure contacts. They close under a positive, controlled pressure. The blade operating mechanism is described as simple, and antifriction bearings are used on main moving parts. Because of its design, the switch is said to be easily operated under "glaze storm" and other severe weather conditions. Switchgear Divs., General Electric Co.

18—SOLENOID VALVE

Features dash pot to eliminate water hammer in high velocity lines

Designated the Series 4000, this direct-operating solenoid valve is designed for normally closed operation. Its design slows down closing action of the valve 1½ to 2 sec, according to manufacturer.

The dash pot construction consists of a bronze piston fitted within top housing of the valve, and pinned to the valve to follow its movement. An upward seating ball check controls flow through a port in this piston. When valve is opened, and piston moves up, liquid above piston flows freely through port so there is no resistance to the instant opening of valve orifice, company states. When valve closes, the ball check closes the port: liquid must flow between piston and housing, a restricted passage which slows closing of valve. Piston and valve are independent of action of valve-opening push rod.

The Series 4000 is built for heavy duty service and to handle temperatures to 400 F. Smaller sizes will operate under differential pressures to 150 lb. Body is bolted together and standard construction is cast iron with bronze piston. All bronze can be furnished. Valve and seat are stainless steel. Available in ¾, 1, 1¼, 1½ and 2 in. sizes. Johnson Corp.

19—BACK PRESSURE VALVES

For use where large quantities of steam must be closely regulated

Described as highly accurate and durable these multiport back pressure and relief valves come in two types: 135VW, for maintaining steam pressure at any desired point between 0 and 20 psi, and 136VW for vacuum service.

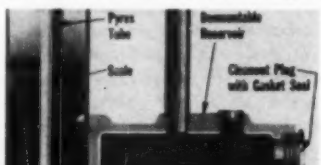
Regulation of inlet pressure from closed to full open valve position is accomplished by several means. The spring is unusually long and its several inches of initial compression are intended to minimize increases in spring tension due to valve lift. The effective area of the cup type inner valve is said to be constant at all positions of valve opening. The velocity head of the steam flowing through the valve is used to increase static pressure in the cup, to overcome small change in spring tension as valve approaches full open.

With these valves, "wire drawing" and "hunting" with pulsating flows are said to be virtually eliminated because individual valve units can be set to open in sequence; at small increments of pressure only one valve at a time is in throttling position. Individual and positive testing or setting of each unit can be done without dismantling valve, it is stated, and repair or replacement of units doesn't prevent operation of valve as a whole. Valve body is of welded, all-steel construction and vertical loads are carried by struts to prevent distortion. Klipfel Valves, Inc., Div., Hamilton-Thomas Corp.

20—MANOMETERS

Are designed for easy cleanout and minimum mercury contamination

To prevent contamination of indicating liquid, the drain and cleanout plugs of these manometers are straight-



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PUMPS — Integral motor and coupled types. Sizes and ratings to 2500 GPM.

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ALLIS-CHALMERS

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threaded and gasket-sealed, and the reservoir and metal passages are lined with a thermosetting plastic. This lining is used to protect liquid from contact with metal and reduce frequency of cleaning; it is described as nearly glass-hard and resistant to acids, alkalis and thinners.

The drain plug releases liquid through a hole in its center, controlling flow like a drain cock. Cleanout of reservoir is by a plugged opening in the rear, nearly the full height of the reservoir to facilitate removal of gummy deposits. Reservoir is demountable for cleaning connecting tube; if desired, reservoir can be replaced. The glass tube and direct-reading scale are also removable.

Manometers come in 14 lengths with scales from 12 to 116 in. long for use on line pressures to 200 psi. They can be mounted flush, flat on panel, on a wall, or on bench or table by tripod mounting. Reservoir and connecting parts are steel or brass, or stainless steel on request. Available with low reservoir, or with raised reservoir for measuring absolute pressure or both pressure and vacuum. King Engineering Corp.

21—CONSTRUCTION WRENCHES

In 45 and 90 deg bent handle styles, in carbon and alloy steels

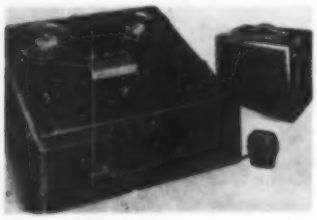
The bent handles of these wrenches facilitate work in close quarters where maximum accessibility and leverage

are required. This type of wrench is particularly useful on flange and pipe line work. Openings are from ⅞ to 2 in. J. H. Williams & Co.

22—MAGNETIC TAPE RECORDER

Is low priced, long-playing unit for industrial applications

With the Knight Magnetic Tape Recorder a 1200-ft reel of tape provides a full hour's recording and may be used over and over, according to manufacturer. It incorporates simplified tape threading and only one control for tape transport mechanism,



with three positions: record-play, off, rewind. Recording speed is given as 7½ in. per sec; rewind speed is 20 times faster.

A special switch is provided to permit muting speaker when recording from microphone and a constant speed capstan drive is used. Recordings can be made from microphone supplied or from any radio, FM tuner or phonograph. Recorder has built-in high-grain amplified and PM speaker for playback, also provision for connection to external amplifier and speaker. Unit can also serve as medium coverage PA system, with an output of 5 w, company explains.

Recorder, housed in portable leatherette case, crystal handmike and cable, all tubes and one half-hour spool of tape are supplied for $99.50. Allied Radio Corp.

23—WIRE CONNECTOR

Is small sized, low priced, and made of porcelain

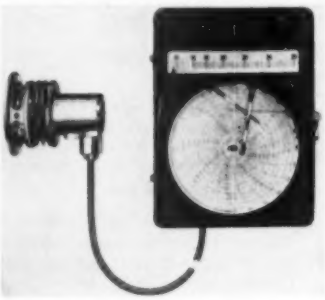
The Model E-1 is intended for joining wire up to four No. 18, particularly in production wiring. It is described as being carefully molded of high grade porcelain. Every thread is perfect, manufacturer states, without broken edges so all wires are completely twisted together and held securely as connector is applied.

The inside of the skirt is threaded from one end of the connector to the other, to make it easier to insert wires and screw on connector. These same threads hold insulation inside the cover, it is pointed out, so the stripped wire ends are completely covered and protected. Ideal Industries, Inc.

24—RADIATION PYROMETER

For indicating, recording or controlling temperatures to 4000 F

The radiation unit, which is the temperature-sensitive head of the Pyrovisor, is mounted on the outside of the furnace or kilns, away from the hot zone, and picks up radiant energy emitted from the surface of the object under measurement. In this way, actual surface temperature measurements



of the work are obtained, rather than the usual furnace atmosphere temperatures. Extremely rapid response is claimed as the outstanding feature of this radiation unit, which is said to produce a 99 per cent response to a temperature change within 1 sec. The Bristol Co.

25—ELECTRICAL TAPE

For use in "hot spots," is made to stand temperatures up to 300 F

"Scotch" brand electrical tape No. 27, is intended for use without other insulating materials. It has a glass cloth backing that is fireproof, and a thermosetting adhesive that sets at 250 F in two hours, or 300 F in one hour, according to manufacturer, and it contains no sulphur. The tape is designed for use where high heat conditions are normal. The glass cloth is unaffected

by moisture, will not shrink, stretch or rot, and has a tensile strength of 150 lb per in. of width, it is stated.

Among uses for the tape are insulating outside transformer coils, taping down hood of armature, making splices in the charger control boxes of foundry cupolas, splicing wires under cooking units of commercial ranges, and protecting feeder cables in lighting pole installations. Minnesota Mining and Mfg. Co.

26—LUBRICATING TOP OILER

Is metering and distributing device for gasoline and gas engines

This oiler has an outlet needle valve designed to permit adjustment of correct air-oil flow for any make of engine. It is intended to overcome any uncertainty of top cylinder lubrication

when top oil is introduced in fuel tank. its uniform and controlled application of top oil helps correct excessive wear, sticky valves, carbon and gum formation, poor pick-up and high crank case consumption, manufacturer states. It is also said to assure immediate lubrication of top cylinders during "cold start" or warm-up period.

Oiler holds oil in a visible container so level can be easily checked. It is operated by vacuum created in the engine which draws the air-oil mixture into the carburetor through intake manifold. Installation is made by screwing or bolting top oiler to bulk head and connecting outlet tube to carburetor through gasket in intake manifold. Universal Lubricating Systems, Inc.

SLUDGE OR SCALE?

There's no place for guesswork in boiler rooms. Scale and adherent sludge cause tube metal to overheat and fail. They often look alike—yet the cause and cure of each may be entirely different. Someone *has* to know this difference or your water treatment may fail.

*Sludge,** a water-formed sedimentary deposit, may include all suspended solids in the water. "Baked-on" sludge is hard and adherent, similar to scale.

*Scale** usually forms from solution directly in place on the surface. It is crystalline and dense in nature.

The Drew System of Water Treatment eliminates guesswork! It starts with proper diagnosis. Corrective treatment, modification of operating cycles, redesign of equipment and other preventive measures are recommended when required. The Drew System is more than superficial service . . . more than chemical "prescriptions" . . . it is specialized service, corrective treatment and preventive measures applied to your individual boiler problem.

*Brief ASTM definition. Send for additional information on the cause and cure of sludge, scale or other water problems.

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DREW PRODUCTS

POWER PLANT Construction News

Bridgeport, Ala.—Tennessee Valley Authority, Nashville, Tenn., has selected site on Guntersville Lake, about 4 miles from Bridgeport, for proposed new steam-electric generating station, to be equipped for an initial rating of 250,000-kw, divided into two units of 125,000-kw each, with high-pressure boilers and other facilities. It will be designated as the Widows Creek power plant, and will represent an ultimate investment of about $37,000,000, including transmission lines, switching stations and other structures.

El Dorado, Ark.—Pan-American Southern Co., plans extension and improvements in power plant at oil refinery, with installation of new boiler, cooling tower and other equipment. Proposed to begin work at early date. No official estimate of cost announced.

Pine Bluff, Ark.—Arkansas Power & Light Co., will secure fund of about $4,000,000, through sale of additional stock to Middle South Utilities, Inc., holding company, a considerable part of proceeds to be used for expansion and improvements in power plants and system, forming part of fund to be used for such work in 1950.

Huntington Beach, Calif.—Beach Union High School District, Huntington Beach, has authorized plans for new boiler house at local high school for central-heating service; two new boilers and accessories will be installed. Allison & Rible, 625 South Westmoreland Ave., Los Angeles, Calif., are architects.

Eldorado, Colo.—Board of Water Commissioners, Municipal Building, Denver, Colo., is projecting plans for new hydroelectric generating station on South Boulder Creek, vicinity of Eldorado. Project will include power dam, water reservoir of 42,000 acre-ft, generating station, switching and substations, transmission lines and miscellaneous structures, and is estimated to cost about $14,850,000. Application for permission has been made to Federal Power Commission.

Pueblo, Colo.—Colorado Fuel & Iron Corp., plans expansion in power plant at steel mill in connection with an extension and improvement program at works, including new mill units and modernization in certain existing facilities. Increased power supply will be required. Entire project will cost about $3,000,000 and will require about 12 months for completion. Work is scheduled to begin soon. Company is a subsidiary of U. S. Steel Corp., New York, N. Y.

Milford, Del.—City Council has plans in progress for extensions and improvements in municipal steam-electric generating station, with installation of equipment for increased output. Estimated cost about $400,000. B. O. Vannort, 513 South Tryon St., Charlotte, N. C., is consulting engineer.

Homestead, Fla.—Town Council has disposed of a bond issue of $300,000, proceeds to be used for expansion in municipal Diesel-electric generating station, including installation of two new generating units and auxiliary equipment. Work is scheduled to begin soon.

St. Petersburg, Fla.—Florida Power Corp., 101 South Fifth Street, has arranged financing through sale of stock, totaling about $2,000,000, proceeds to be used for expansion and improvements in plants and system. Fund will form part of appropriation for 1950.

Travernier, Fla.—Florida Keys Electric Cooperative Association, Inc., plans expansion in Diesel-electric generating station, with installation of a new 1100-kw generator unit and auxiliary equipment. Fund of $365,000 has been arranged through REA for this and certain line extensions.

Whitesburg, Ga.—Georgia Power Co., 75 Marietta St., N.W., Atlanta, Ga., has plans maturing for new power plant in vicinity of Whitesburg. Project will represent large investment—no official estimate of cost announced. Proposed to begin work at early date.

Chicago, Ill.—Commonwealth Edison Co., 72 West Adams St., is arranging a budget of about $290,000,000 for expansion and improvements in plants and system over a 48 month period, from 1950 to 1953, inclusive, including increased generating facilities, power substations, transmission and distributing lines, and other facilities.

East St. Louis, Ill.—Board of Education, School District 189 of St. Clair County, plans installation of boiler plant for central-heating service in new multi-story high school. Entire project reported to cost in excess of $2,500,000. Proposed to begin work next spring. Albert M. Goedde, First National Bank Bldg., East St. Louis, is architect.

Peoria, Ill.—Central Illinois Light Co., 316 South Jefferson Ave., has arranged a construction budget of about $13,500,000 for expansion and improvements in plants and system during a 24-month period, 1950 and 1951, inclusive. During the first year, it is estimated that approximately $5,000,000 will be expended, with remainder of $8,500,000 to be used in second year. Work will include increased generating facilities, power substations, transmission and distribution lines, and miscellaneous work.

Ford, Ky.—East Kentucky Rural Electric Cooperative Corp., Danville, Ky., will have plans prepared soon for new steam-electric generating plant in vicinity of Ford (Clark County), where site has been selected. It will be equipped for initial capacity of 40,000-kw. Entire project is estimated to cost about $12,265,000, including about 600 miles of transmission lines, power substations and other operating facilities. Financing in that amount is being arranged through REA.

Frankfort, Ky.—Public Buildings Administration, 18 and F Sts., N.W., Washington, D.C., plans installation of boiler plant for central-heating service in new postoffice and court house building at Frankfort. Cost estimated about $1,000,000. Plans are scheduled to be prepared soon.

Owensboro, Ky.—Green River Rural Electric Cooperative Corp., Owensboro, and Henderson Union Electric Cooperative, Inc., Henderson, Ky., are planning joint construction of new steam-electric generating plant to serve combined area. Estimates of cost are being made. Proposed to arrange financing through Federal aid.

New Orleans, La.—Louisiana Power & Light Co., 142 Delaronde St., Algiers, New Orleans, is arranging for financing in amount of $4,500,000, through sale of stock to Middle South Utilities, Inc., holding company, considerable portion of proceeds to be used for extensions and improvements in power plants and system. This will comprise part of fund to be used by company for such purpose in 1950.

Boston, Mass.—Public Buildings Administration, 18 and F Sts., N.W., Washington, D.C., plans boiler plant for central-heating service in new multi-unit marine hospital at Boston. A refrigerating plant and air-conditioning system will be installed. Entire project is estimated to cost about $2,900,000. Plans will be prepared soon.

Augusta, Me.—Central Maine Power Co., 9 Green St., is arranging an expansion and improvement program in plants and system in 1950 to cost about $8,000,000, including increased generating facilities, power substations, transmission lines and other facilities. In addition, certain projects will be carried forward from 1949, with several million dollars available from fund of that year. Company has plans for new hydroelectric generating station at Caribou, Me., with work scheduled to begin at early date.

Albion, Mich.—Bd. of Trustees, Sheldon Memorial Hospital, Albion, has plans in progress for new boiler plant for central-heating service at institution. This is part of a general expansion and improvement program, entire project reported to cost about $500,000. Smith, Hinchman & Grylls, Inc., Marquette Bldg., Detroit, Mich., is architect and engineer.

Detroit, Mich.—Murray Corp. of America, Inc., 7700 Russell St., steel automobile bodies, etc., has plans in progress for new power house at local plant. Proposed to carry out work soon. No estimate of cost announced. Boddy-Benjamin Associates, Inc., 2210 Park Ave., Detroit, is engineer.

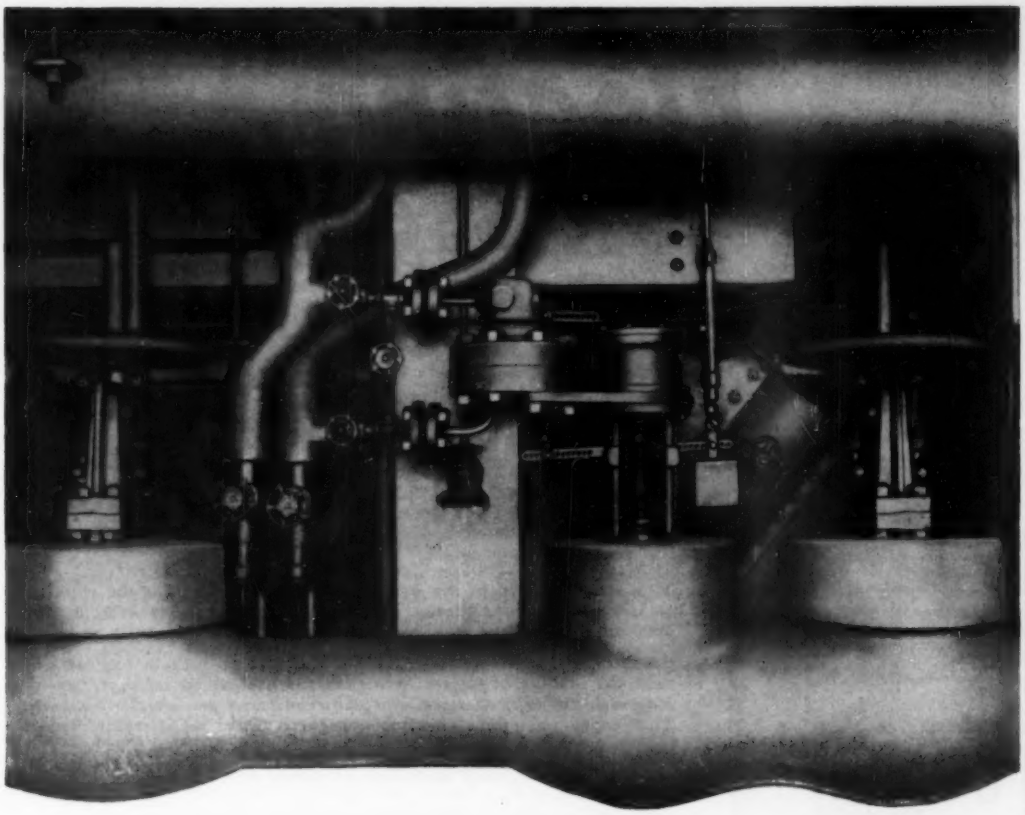
Bellevue, Neb.—Loup River Public Power District, Columbus, Neb., has approved plans for addition to steam-electric generating station at Bellevue, and will proceed with superstructure at once. Cost reported over $500,000.

Gonic, N. H.—New England Brick Co., has authorized plans for new boiler house at yard. Project will be carried out in connection with general expansion and improvements in plant, entire development to cost close to $200,000. Anderson, Nichols & Co., 53 State St., Boston, Mass., are architects.

Carlsbad, N. M.—Duval Texas Sulphur Co., Niels Esperson Bldg., Houston, Texas, plans power plant at proposed new potash mining and refining plant in vicinity of Carlsbad, entire project reported to cost over $6,000,000. Work is scheduled to begin in 1950 and will require about 24 months for completion. Company is an interest of United Gas Corp., 1120 Texas St., Houston.

Carthage, N. C.—Carthage Fabrics Corp., recently chartered, plans boiler house at proposed new rayon fabric mill on local site. Entire project will cost in excess of $450,000. E. Sontag, president, Faxon Fabrics Corp., 325 Bonney St., New

(Continued on page 116)



How to hold boiler water level closely

When you want to hold boiler water level within close limits, no matter how widely or rapidly loads change, depend on COPES Flowmatic—the simplest, most widely used flow-level type of feed control.

This industrial installation, for example, is on a 660-psi Riley Steam Generator rated at 225,000 pounds per hour. Loads constantly fluctuate 10,000 pounds per hour over a total range from 150,000 to 265,000 pounds per hour. Yet water level is held within plus-or-minus one inch at all times.

More than 1200 Flowmatic users like the coordination of influences from steam flow and water level to get the exact feed needed for close level control. They also like the ease with which plant personnel can handle all maintenance.

For a complete performance report on installation illustrated above, write for Bulletin 485.

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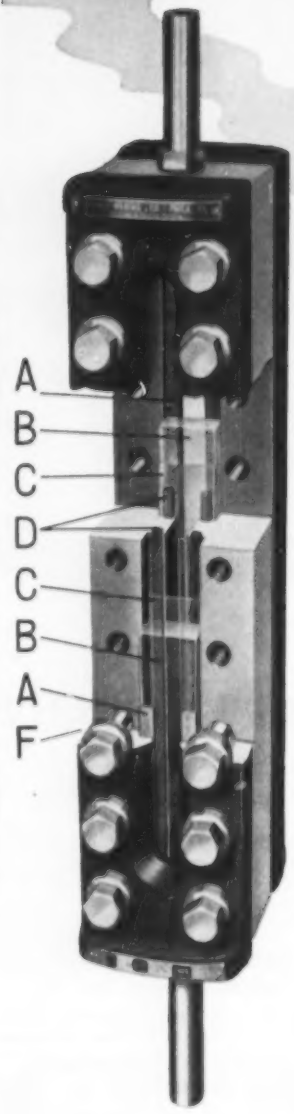
"Floating Assembly" Water Gage

REDUCES LEAKAGE and GLASS BREAKAGE



Yarway offers help to the steam plant engineer who has the problem of leakage and glass breakage on flat glass water gages. It's "floating assembly."

Research shows a flexible feature is required to prevent leakage and excessive loading of glasses. *Spring cones (F), under the cap nuts fastening independently adjusted covers and glasses in place, provide this flexibility.* The "floating assembly" loading is predetermined . . . is maintained by cap screws which shoulder on the insert body, limiting the spring cone compression to that required. *Front and back cover plates are independently adjusted.*

Engineers say these features help them. They may help you, too.

For the full story on "floating assembly" and the Yarway line of water columns and gages, send for Bulletin WG-1811. Or see a model demonstrated in your own plant. Write . . .

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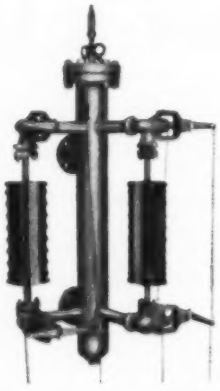
Cut-away section of Yarway Flat Glass Gage. Front and back cover plates are independently fastened to body by special shouldered cap screws fitted with spring cones (F) which automatically limit the pressure on glasses and gaskets and at the same time allow for expansion and contraction.

Special molded gaskets (D) provide tight pressure-sealed joints between body and glasses. Cushioned asbestos gaskets (A) are placed between cover plates and outer faces of glasses (B). Inner surfaces of glasses are protected by India ruby mica (C).



Yarway Water Column with two Yarway Flat Glass Gages. For pressures from 400 to 2,300 psi.

YARWAY

WATER COLUMNS AND GAGES

LETTERS TO THE EDITORS

BALANCING ROTORS

I HAVE just read with interest Mr. Schubert's article, "Balancing Rotors Without Special Equipment"[1] because this same method was used a number of years ago by a Service Engineer called in at the plant in which I was employed as a maintenance mechanic. The unit involved was a 1500 hp synchronous motor in which the field had been rewound. When the assembly was completed and the motor started the vibration was so severe that the machine could not be operated. As I recall, we worked for a couple of days before the vibration was reduced to less than two mils, which was considered satisfactory.

This was my first experience with balancing, however since then I have performed several balancing jobs, and the location of the heavy points was accomplished much easier by means of a General Radio Strobotac. The tube in this instrument may be fired by an external contactor which can be simply made by mounting an insulated bracket and pointed screw in such a manner that the screw may be brought in contact with the shaft. Before the machine is started numbers are marked around the shaft periphery close by the contactor and the arc of contact may be easily noted. This instrument is relatively inexpensive and a number of other uses, such as slowing down motion for observation and measuring speed, will be found for it.

A method I used to align the bearings in a 125 MGD vertical pump proved very satisfactory and consisted of an insulated plumb line made up of a 0.013 in. music wire and a 50 lb bob. This pump had a shaft approximately 50 ft long and the impeller and guide bearings were aligned by using an inside micrometer, contact with the plumb wire being indicated by a 3-volt light, the bearing shell forming one side of the circuit and the wire the other. A comparatively inexperienced mechanic could set a bearing within 0.001 in. by this method.

These schemes are not original with me but I do not recall having seen them in print in magazines such as POWER GENERATION.

Arlington, Va. A. A.

[1] Page 94, November 1949 issue.

THE NEW ERA

THE SPLENDID summing up of fifty years of development and progress in the power industry in the January issue, recalls to an old timer's mind, the vast difference between the glittering assemblies of automatic equipment we call power plants today, compared to what we boastfully referred to as "our power plant" in the early years of the twentieth century. This ancient power plant was granted an unobtrusive corner of a building area, or a rear yard, apparently with the main idea of keeping it, out of sight, out of mind. Sometimes, a small building was erected for it, coupled to a smoke stack and often the whole unit was placed underground, so low, in fact, that pumps were needed to keep the floors dry from surface water and seepage.

As a rule, one or more old fashioned hrt boilers were placed tight together, a feed pump on the floor beside one, injectors on both, overflowing to the floor with each start and stop, coal *hole* or yard at some more or less inconvenient distance either discharging on the boiler room floor or entailing wheelbarrows to dump on that floor.

Dumping, shovelling, and ash removal, all by hand, produced an enormous amount of dust which covered and clung to every horizontal surface including wet floors. Often the floors were dirt. This dust was produced every hour of the twenty-four and no matter how the engineer or fireman tried, he was soon forced to give up in disgust the job of keeping his boiler tops and equipment clean.

The engineer, poor soul, was required to work 12 hours a day, seven days a week and often had to come down at night for some repair job. Shovelling, wheeling coal and ashes, looking after his pumps, he had few odd moments to spare to wipe or sweep. Engineers of that era accordingly developed habits that are out of order now.

They were primarily interested in turning fuel into steam, good operating condition of their equipment and above all keeping costs down.

During the years of fugiting tempus, these plants were overloaded by additional premises or equipment. A wall would be knocked out to allow extension of boiler-room for another unit plus its auxiliaries, further crowding things to such an extent that there wasn't sufficient room for a chair and small desk at which one might eat a lunch and keep records. Even the chair and desk were perforce coopered up out of scrap lumber. Who ever heard of furniture supplied to a boiler plant? At that, these boys managed to produce 7 or 8 lb of steam per pound of fuel, fuel varying from soft slack down to coke breeze. *They produced.* Of course no visitors were ever conducted into the steam plant because under these conditions it could not be kept presentable.

Manufacturers of equipment were mainly responsible for the radical changes that took place in the past 25 years. By experiment and research they could prove that automatic stokers turned 10 per cent of presently waste chimney gases into steam, that efficient feed heaters utilized waste steam in preheating

(Continued on page 65)

POWER GENERATION ON MICROFILM FOR LIBRARIES

Technical Publishing Company has entered into an agreement with University Microfilms, Ann Arbor, Michigan, to make available to libraries issues of POWER GENERATION in microfilm form.

One of the pressing problems facing all types of libraries today is that of providing adequate space for a constant flood of publications. Periodicals pose an especially difficult problem because of their bulk and number.

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Power Generation's FEATURE OF THE MONTH

Design of Purging Systems For Hydrogen Cooled Electric Machines

This article by Messrs. Snell and Schmid gives a complete description of the methods which have been developed for the purging of hydrogen cooled electric machines by the use of carbon dioxide, with all the necessary technical data on the characteristics of the fluids involved under various conditions of pressure, temperature and mixture. This article represents years of effort on the part of many individuals and it should be of value to all operating engineers in charge of hydrogen cooled machinery

By D. S. SNELL and R. C. SCHMID, General Electric Company

Introduction

IN THE PROCESS of interchanging hydrogen and air in hydrogen-cooled machines, a purging agent is generally employed to remove the air initially within the machine casing before admitting hydrogen, and to remove hydrogen from the casing before opening the latter to atmosphere for inspection or repairs. Of the different gases which could be used for this purpose, carbon dioxide seems best adapted and is most widely used for the following reasons: (1) It is inert, not supporting combustion; (2) It is inexpensive, and readily obtainable in different localities; (3) It has a high density relative to air and hydrogen, hence has relatively low diffusivity into these gases; and (4) It may be analyzed, in combination with air or hydrogen, by the same methods employed in the analysis of hydrogen-air mixtures. Although nitrogen is also one of the inert gases, and has sometimes been used in purging hydrogen-cooled machinery, it does not possess the other advantages of carbon dioxide, hence has not been widely used.

In Part I of this article, the various characteristics of carbon dioxide, which distinguish this gas from other gases, are described, and the different types of containers in which carbon dioxide is commercially supplied, are discussed. The various types of purging systems used with hydrogen-cooled machinery are described, and data from factory and field tests on these systems are given. In Part II, the temperature and pressure conditions existing in a carbon-dioxide cylinder during rapid discharge, in both the upright and inverted positions, are determined, and from this determination curves are derived giving the required rates of cylinder pressure drop to obtain specified purging rates. Data are also given on the energy requirements of heaters used with certain types of purging systems, and data on the design of immersion-type heaters are given.

Those who remember the article on nine year's of operating experience with hydrogen cooled generators in the May 1947 issue of Power Plant Engineering will need no introduction to the first of the authors of this article on purging hydrogen cooled machines. D. S. Snell has spent many years in this field and is one of the foremost authorities on the subject in this country. He is a graduate of Union College with the degree of B.S. In Electrical Engineering (1919) and M.S. in Electrical Engineering (1921). Following graduation he served a year as instructor in Electrical Engineering at Union College, leaving in 1922 to enter the General Electric Co. in the General Engineering Department. After two years in this department he transferred to the Turbine-Generator Engineering Division where he has since been engaged in development and design work. R. C. Schmid, the second of the authors was born in San Diego, California, January 3, 1918. He received his B.S. in Electrical Engineering from the University of Southern California in 1940 and his B. Eng., Majoring in Mechanical Engineering, in 1941. From June 1939 until February 1941 he was with the Generation Department of the Los Angeles Dept. of Water and Power. In 1941 he enlisted in the U.S. Marine Corps and in 1943 was commissioned Captain with duties as Officer in Charge of the Marine Corps Radar Schools. During 1944 and 1945 he was Major with duties as Officer in Charge Radar and Radio Supplies and Repair for Marine Corps in Central Pacific. In April he was employed with The General Electric Co. in the Design Section of the Turbine Generator Division. During 1947 he was with International G.E. and in 1948-49 with General Electric in the Apparatus Service Shops at Los Angeles. Now, he is Service Engineer in the Industrial Division of the Los Angeles Office of G. E.

PART I

Characteristics of Carbon Dioxide

Carbon dioxide, at ordinary temperatures and pressures, is a colorless gas, obeying approximately the laws of a perfect gas. At moderately high pressures, it liquefies, and further compression, or reduction in temperature, causes solidification. These three states of carbon dioxide —solid, liquid and gaseous—are shown graphically in the equilibrium chart of Fig. 1, as defined by temperature and pressure. For pressures and temperatures to the right of the saturation curve, carbon dioxide exists as a superheated vapor; between the saturation and freezing curves is represented the liquid state; while the region to the left of the freezing curve represents the solid state. At a temperature of -70 F and a pressure of 75 psia, any one of the above three states may be

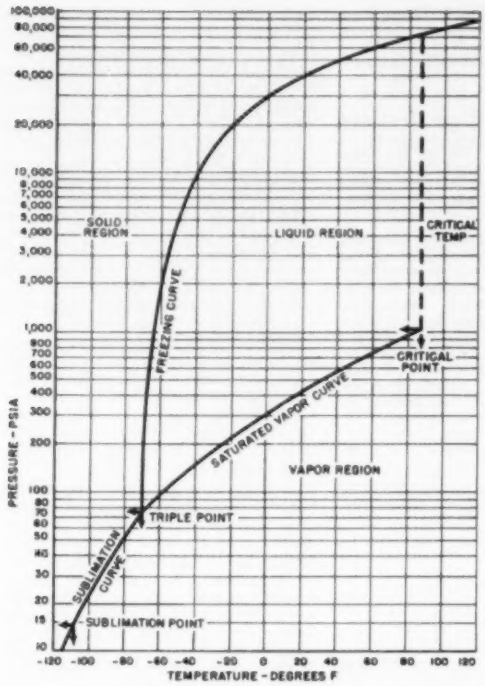

Fig. 1. Equilibrium curves for carbon dioxide

present, hence this point is designated as the "triple point."

Above a temperature of 88 F, carbon dioxide cannot exist as a liquid, hence this temperature is termed the "critical" temperature; while the state corresponding to this temperature at 1066 psia is designated as the "critical point." At this point the density of the saturated vapor in the container equals that of the liquid and there is mutual solubility between the gas and liquid. At -109 F and atmospheric pressure, the solid CO_2 sublimes into vapor; this point being designated the "sublimation point."

Because of the foregoing characteristics of carbon dioxide, the pressure in a container of this gas is not alone a measure of the amount of CO_2 present; since, as long as any liquid is present, the pressure existing is that of the saturated vapor, which is determined by the temperature in accordance with the saturation curve of Fig. 1. Also, depending on the degree of filling of the container and the temperature, the pressure may be due to any one of three factors: (1) the pressure of the saturated vapor in presence of liquid, (2) hydrostatic pressure of the liquid, or (3) pressure of the superheated vapor. In Fig. 2 curves are given showing the pressures in a standard 50 lb CO_2 cylinder for different values of the combined density of the gas and liquid in the cylinder, at different temperatures. These curves may be used in estimating the contents of partially-discharged cylinders, from measurements of the cylinder pressure and room temperature, thus saving the trouble of weighing the cylinders to obtain this information.

At 70 F and atmospheric pressure, carbon dioxide has a density of 0.115 lb per cu ft. The contents of a 50-lb cylinder will expand, therefore, on discharge to atmosphere, to $50 \div 0.115 = 434$ cu ft at 70 F. Multiplying this quantity by a factor to take account of the loss of availability of some of the cylinder contents through freezing, and dividing into the estimated amount of CO_2 required to purge a given casing volume, gives the number of 50-lb cylinders required in the operation.

Types of CO_2 Containers Used

Carbon dioxide is generally supplied commercially in cylinders containing 50 lb of CO_2 in the liquid and gaseous states. A standard cylinder has a volumetric capacity of 1.355 cu ft, an empty weight of approximately 105 lb, and contains when full 45 lb of CO_2 liquid and 5 lb of CO_2 vapor, at 70 F. In some localities, cylinders of 20 and 100 lb capacity are also available. The cylinder valve is provided with a ⅛ in. orifice, through which gaseous CO_2 is discharged with cylinder upright, and liquid CO_2 (which changes at once to "snow" on discharge to atmosphere) is discharged with cylinder inverted.

A second type of container sometimes used is the siphon-tube cylinder. This cylinder is of the same design as the standard cylinder, except that a ⅛ in. copper tube is attached to the inlet of the cylinder valve, which extends nearly to the bottom of the cylinder. This arrangement permits CO_2 liquid to pass to the cylinder valve with cylinder in the upright position. Cylinders of this design provided with fire-extinguishing equipment are provided with a ⅜ in. tube and ⅜ in. orifice in valve, to provide maximum rate of discharge.

A third type of CO_2 container frequently used in the purging operation is the dry-ice flask, the application of which was described in a previous article (1). With this type of container, a connection is taken from the top of flask if gaseous CO_2 is required, and from the bottom if liquid CO_2 is required.

A fourth type of container which has been sometimes used with purging systems is the low-pressure CO_2 storage tank, in which CO_2 is maintained, through refrigeration, at 0 F and 300 psia. This arrangement is usually supplied in connection with fire-extinguishing equipment, and is used only secondarily in the purging operation.

Various Purging Methods

In Fig. 3 are illustrated diagrammatically six different methods which have been employed—or their use has been contemplated—in the purging of hydrogen cooled machines with carbon dioxide. In methods A, B and C upright cylinders are employed (or other types of containers, arranged to discharge gaseous CO_2), while methods D, E and F utilize cylinders in the inverted position (or use other types of container arranged to discharge liquid CO_2).

In the different methods here considered, CO_2 is admitted to the bottom of the machine casing through a perforated distribution pipe, or through nozzles (method D) located in the bottom of the casing, and the air or hydrogen to be displaced is discharged from a similar distribution pipe located in the top of the casing, the latter pipe normally being used for the introduction of hydrogen. A connection from the hydrogen feed pipe to the station vent line (see Fig. 4) permits the scavenged gas to be discharged outside the station. With this method of CO_2 admission, an admission rate of between 30 and 100 cfm, depending on the volume of the casing being purged—which may be assumed to range from 600 to 2400 cu ft—will insure minimum mixing of the CO_2 admitted with the gas being removed, thus insuring minimum wastage of CO_2. For removal of air from a casing to 20 per cent air in CO_2, from 1 to 1¼ casing volumes are normally required, while for removal of hydrogen to a content of

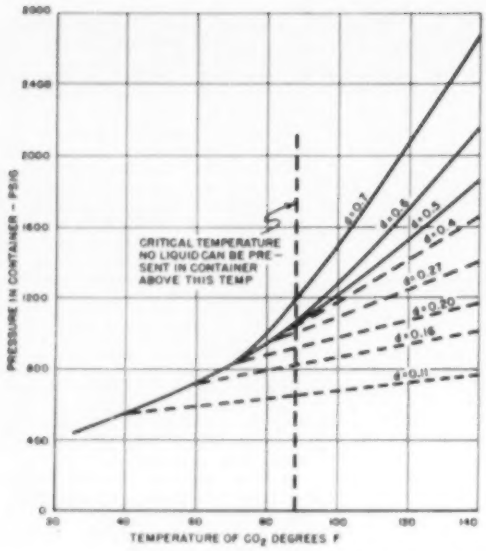

Fig. 2. Pressures exerted by CO_2 on walls of container at different temperatures

Volume of standard 50-lb cylinder = 1.355 cu ft. Combined density of CO_2 in standard cylinder when full = 0.592

Note: For combined densities of 0.5 and over, volume of liquid in cylinder increases with temperature until liquid fills cylinder. For combined densities below 0.46, the volume of liquid in cylinder decreases as temperature increases

$$d = \frac{\text{Weight of } CO_2 \text{ in container (liquid + vapor) lb}}{62.4 \times \text{volume of container in cu ft}}$$

For Standard cylinders, use:

Curve for d = 0.6	for cylinders	100%	full
Curve for d = 0.5	for cylinders	84%	full
Curve for d = 0.4	for cylinders	68%	full
Curve for d = 0.27	for cylinders	46%	full
Curve for d = 0.20	for cylinders	34%	full
Curve for d = 0.16	for cylinders	27%	full
Curve for d = 0.11	for cylinders	18%	full

10 per cent H_2 in CO_2, from 1.7 to 2 volumes of CO_2 may be required.

In reference (2) is given an account of the filling of the Navy dirigible ZMC-2 with CO_2 in this manner, preparatory to filling the casing with helium. In this case, in place of a distribution pipe for CO_2 admission, three 6 in. openings along the bottom of the dirigible were used. Observation of the illuminated interior of the casing through peepholes in the sides, during the filling process, revealed a distinct line of demarcation between the air and CO_2 in the casing, the moisture condensing out of the air lying as a blanket of fog on the colder layer of CO_2 beneath; thus practically complete stratification was realized. A purging rate of 170 cfm was used, the volume of the dirigible being 200,000 cu ft, and 1.17 volumes of CO_2 were used to obtain a 99 per cent concentration of CO_2 in the discharged gas.

In method A, Fig. 3, gaseous CO_2 is admitted to the machine casing from upright cylinders with one cylinder discharged at a time, the rate of discharge being controlled by the cylinder valve. A relief valve at the manifold, set at 40 psig limits the discharge rate.

Method B is similar to A, except that no relief valve is provided, several cylinders are discharged together, and the rate of discharge is controlled with hand-valve V. In both methods A and B an appreciable fraction of the cylinder contents becomes unavailable through freezing, although a somewhat smaller amount is lost with method B than with method A since for a given total rate of discharge the rate per cylinder is less with method B, thus permitting more heat to be absorbed by the CO_2 in cylinder during discharge, from the cylinder walls and from the room air.

In method C freezing of the cylinders during discharge, and the

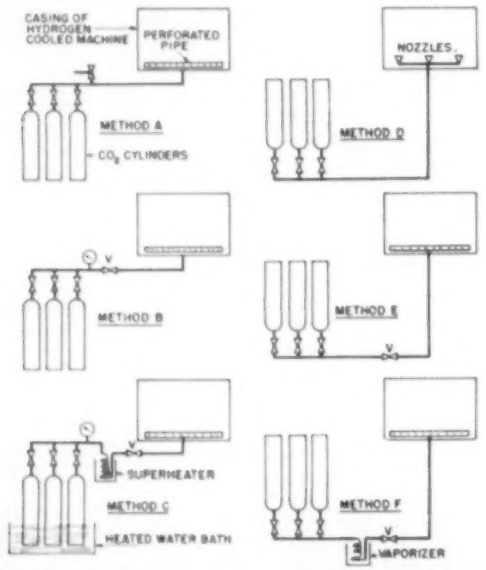

Fig. 3. Different methods used in purging hydrogen cooled machinery with carbon dioxide

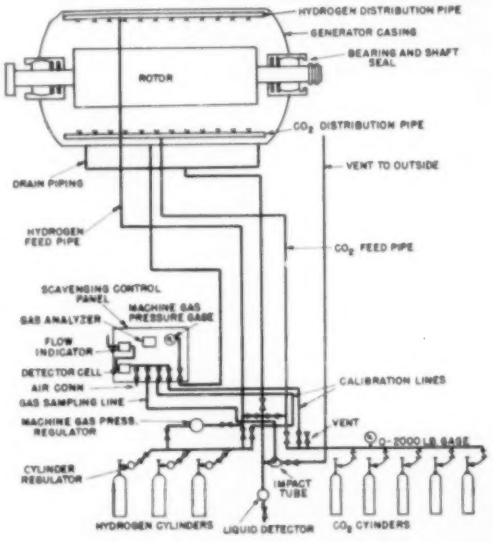

Fig. 4. Arrangement of gas control system for a hydrogen cooled generator

Fig. 5. Scavenging control panel for hydrogen cooled generator

possibility of freezing the control valve are eliminated through the provision of a heated water bath for the cylinders and a superheater ahead of the control valve. This arrangement has been frequently used.

In method D, liquid CO_2 from the containers is piped to a limited number of nozzles in the machine casing, where it is discharged as "snow" or vapor. This method eliminates trouble from freezing, but would not ensure as complete purging of the various compartments of the machine casing as is obtained when a distribution pipe is used. Also, the nozzles, which are required to have very small orifices, might become plugged with foreign matter and would be relatively inaccessible for servicing. For these reasons this method has not been used in practice. Its principal merit is in its ready adaptability to a fire-protection system for hydrogen-cooled generators which may operate for extended periods with air cooling and such protection may be considered desirable.

In method E, liquid CO_2 from the containers is converted into "snow" or vapor at the hand-valve V and discharged in this form into the machine casing. This method has been successfully used in many cases, but since it may produce harmful stresses in the casing parts through extreme reductions in temperature, its use cannot be recommended.

In method F, the liquid CO_2 discharged from the containers is passed through a vaporizer, which permits gaseous CO_2 at normal temperature to be discharged into the machine casing, the rate of discharge being controlled by hand-valve V. Of the different methods herein described, this method is by far the most rapid and efficient. However, due to the additional equipment required, its use has been confined to installations in which single purging system is used to supply several hydrogen cooled machines or where the machine is of sufficiently large capacity to justify the extra cost.

Because of the greater convenience of using upright cylinders, without heaters, methods A and B,

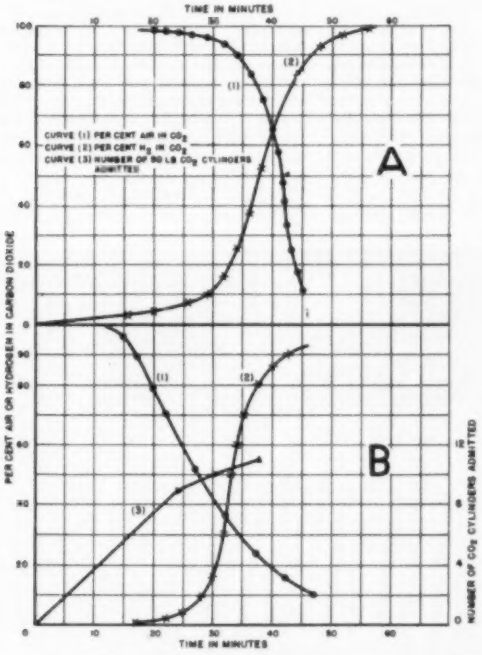
TIME IN MINUTES
CURVE (1) PER CENT AIR IN CO_2
CURVE (2) PER CENT H_2 IN CO_2
CURVE (3) NUMBER OF 50 LB CO_2 CYLINDERS ADMITTED
PER CENT AIR OR HYDROGEN IN CARBON DIOXIDE
NUMBER OF CO_2 CYLINDERS ADMITTED
A
B
(1)
(2)
(3)

Fig. 6-A. Variation of per cent CO_2 and hydrogen in machine casing during purging and filling operation for a 60 Mw generator, using method B (upright CO_2 cylinders without heaters). Volume of casing 1600 cu ft. Five 50-lb cylinders used. Average purging rate 36 cfm at 70 F

Fig. 6-B. Similar curves but for a 95 Mw generator using method F (inverted CO_2 cylinders with vaporizer). Volume of casing 2400 cu ft. Eleven 50-lb cylinders used. Average rate of purging 119 cfm at 70 F

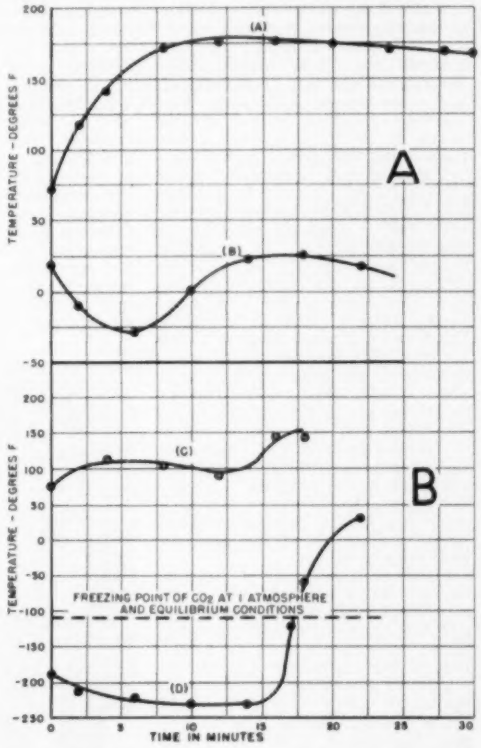

Fig. 7-A. Temperatures of CO_2 after expansion in factory tests using upright cylinders with heaters. Curve (a) Discharge rate 6.6 lb per min. No cylinder heaters used. Heat to superheater 65 Btu per lb. Curve (b) Discharge rate 8.8 lb per min. Heat to cylinder water bath 25 Btu per lb. Heat to superheater 23 Btu per lb

Fig. 7-B. Temperatures of CO_2 after rapid expansion in factory tests using inverted cylinders with vaporizer. Curve (c) Discharge rate 11.1 lb per min. Initial cylinder temperature 76 F. Heat added 122 Btu per lb. Curve (d) Discharge rate 8.7 lb per min. Initial cylinder temperature 70 F. Heat added 69 Btu per lb

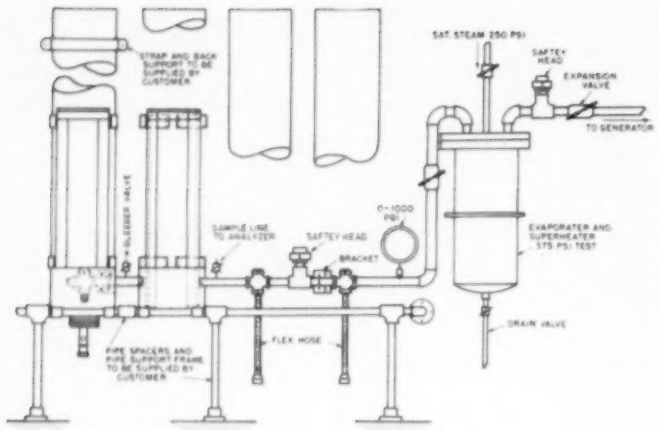

Fig. 8. Design of purging system using inverted cylinders

Fig. 3, have been more generally employed in the purging of hydrogen cooled machinery than the other methods described. Although an appreciable amount of the cylinder contents are made unavailable through freezing with these methods, this disadvantage is usually considered to be offset by their greater simplicity. In Fig. 4 is shown a diagram of the gas-control system for a hydrogen-cooled generator, using method B. A 5-cylinder CO_2 manifold is provided in this arrangement, with 2000 lb pressure gage having dial marked to show the saturation temperatures of CO_2 at different pressures, in accordance with the saturation curve in Fig. 1. A scavenging control panel is provided, Fig. 4 and 5, located adjacent to the gas manifolds, having a gage for indicating the gas pressure in the generator casing, and a gas analyzer for measuring the percentage CO_2 in the scavenged gas. An impact tube in the discharge pipe from generator casing carries a sample of the scavenged gas to the analyzer. Connections from the hydrogen and CO_2 manifolds to the scavenging panel permit calibration of the analyzer with the pure gases.

Figure 6a shows a set of "purging curves" taken with the above arrangement when placing into service a 60 Mw hydrogen cooled generator. These curves show the time variation of the percentage CO_2 in the scavenged gas during the removal of the air in casing with CO_2 and in the subsequent filling with hydrogen. The casing of this generator, having a volume of 1600 cu ft, was purged to a 10 per cent air content in 45 min, using 5 CO_2 cylinders, at an average rate of about 36 cfm. In filling the casing with hydrogen to a purity of 99 per cent, approximately one hour, and the introduction of 14-200 cu ft cylinders were required.

In a number of installations, method C, using a heated water bath for the cylinders and a superheater ahead of the control valve, has been successfully used. In a factory test using this method, four cylinders containing 194 lb of CO_2 were discharged in 22 minutes (at rate of 8.8 lb per min, or 77 cfm at 70 F and atm. pres.) with 25 Btu per lb of CO_2 discharged added to the cylinders through the water bath and 23 Btu per lb added to the gas in the superheater. Curves showing the temperature of the gas discharged from the control valve at different times during this test are shown in Fig. 7a, together with similar curves from a test in which the heater for the cylinders was omitted and 65 Btu per lb added in the superheater, for a discharge rate of 6.6 lb of CO_2 per min. The curves from the latter test indicate that more heat than was necessary was added in the superheater, the temperatures obtained in the test with lower input being sufficiently high for all practical purposes.

Purging Systems Using Inverted Cylinders with Vaporizer

In order to determine the practicability of this purging method (method F, Fig. 3) extensive factory tests were made, under the direction of the second of the authors, in which four inverted CO_2 cylinders were discharged together in the inverted position through a vaporizer and a piping arrangement designed to simulate service conditions. The test arrangement included an orifice at end of the discharge line to limit the rate of discharge, and several thermocouples for measuring temperatures of the gas in the different sections of the system. The results of the principal tests are summarized in Table 1, and indicate that very high rates of discharge may be obtained with this method, with no loss of CO_2 through freezing, or other difficulties. In test No. 1, however, failure to provide sufficient heat input to the vaporizer resulted in obtaining temperatures on the discharge side of control valve considerably below the sublimation temperature of CO_2. In Fig. 7 these temperatures are shown for different times during the test, together with temperatures from tests Nos. 2 and 3 shown for comparison. The latter temperatures, obtained with adequate heat input to vaporizer, are satisfactory; the temperatures in test No. 1 however, if obtained in purging an actual machine, could

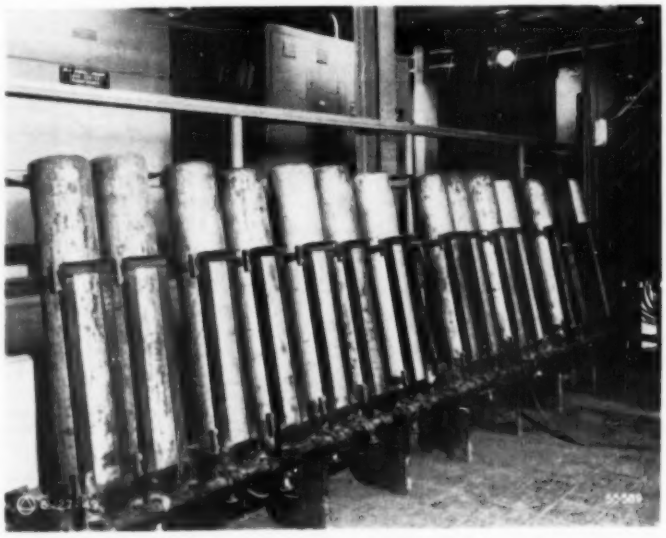

Fig. 9. Photograph of CO_2 system for purging 4 hydrogen cooled generators in Sewaren Station of Public Service Electric & Gas Co., N. J.

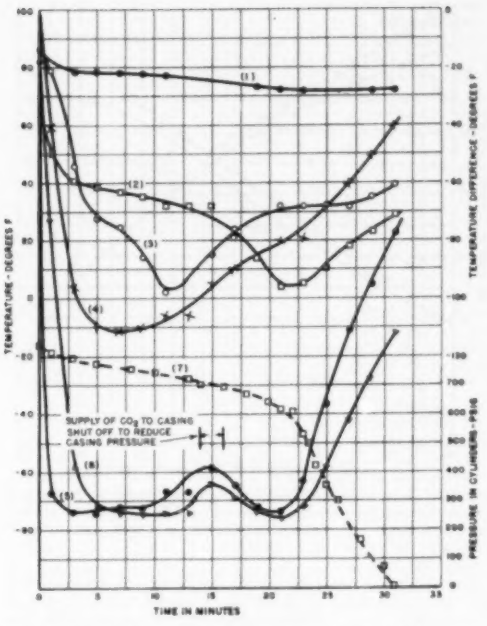

Fig. 10. Temperatures obtained in a generator casing during purging operation using inverted CO_2 cylinders without vaporizers.
Curve (1) Casing temperature 4 ft from feed pipe entrance
Curve (2) Casing temperature at feed pipe entrance
Curve (3) Casing temperature 2 ft from feed pipe entrance
Curve (4) Temperature difference, (curve 6)—(curve 2)
Curve (5) Temperature of feed pipe at control valve
Curve (6) Temperature of feed pipe at entrance to casing
Curve (7) Pressure in CO_2 cylinders

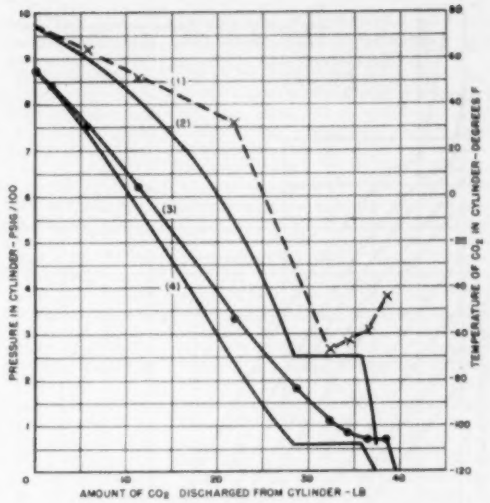

Fig. 11. Calculated and test values of pressure and temperature in a CO_2 cylinder during rapid discharge in upright position, with heat added. For cylinder at 72 F initial temperature. Test cylinder discharged in 30 min before freezing
Curve (1) Temperature of CO_2 in cylinder. (Test)
Curve (2) Temperature of CO_2 in cylinder. (Calculated)
Curve (3) Pressure of CO_2 in cylinder. (Test)
Curve (4) Pressure of CO_2 in cylinder. (Calculated)

introduce harmful stresses into the casing. Later tests on an actual installation, with the vaporizer omitted, gave temperatures well above the sublimation temperature (see Fig. 10), indicating that the factory test arrangement did not completely simulate service conditions. In Appendix III an explanation is offered for the low temperatures obtained in test No. 1.

A design of a purging system, using inverted CO_2 cylinders with vaporizer, is illustrated in Fig. 8. In Fig. 9 is shown a photograph of an installation built to this design which is used to serve four 100 Mw hydrogen cooled generators in one station. This installation was provided with a 15 kw immersion type electric vaporizer, instead of the steam type shown in Fig. 8, since there was no supply of low-pressure steam available. (The steam type of vaporizer is to be preferred, however, due to the higher temperature difference available between the heating fluid and the cold CO_2 liquid.) In Fig. 6b are shown a set of purging curves obtained with the system shown in Fig. 9 at the time of placing one of the hydrogen-cooled generators in service. The volume of the generator casing was 2400 cu ft and the purging operation was carried out with cylinders at an initial temperature of 42 F. Eleven 50 lb. CO_2 cylinders were used in removing the air from the casing, admitted in 38 minutes (average rate 14.5 lb per min, or 119 cfm at 70 F and atm. pres.). At this high discharge rate the vaporizer was heavily overloaded, so that the CO_2 feed pipe was frosted up to the generator casing. (The capacity of this vaporizer has since been doubled, so that moderate temperatures for the gas leaving vaporizer are now obtainable.) The high rate of CO_2 admission in this test resulted in the use of about 1.9 casing volumes of CO_2, instead of the usual 1 to 1.25, to obtain 90 per cent CO_2 in the scavenged gas. The total purging and filling time in this test was only 1.5 hr which, for a generator of this size must be considered as very rapid, and as amply demonstrating the speed of this purging method.

Cooling Effect on Machine Casing Obtained in Purging with Liquid CO_2 Without a Vaporizer

In numerous instances — usually where siphon-tube cylinders have been available — the casings of hydrogen-cooled machines have been purged using method E. This results in discharging CO_2 "snow" into the casing, and in one instance, in which CO_2 from the bottom of a low-pressure storage tank was used in purging the casing of a large hydrogen-cooled frequency changer, sufficient chilling of the CO_2 feed pipe at entrance to the casing occurred, to fracture the weld at this point, requiring repairs. To determine the effect of discharging CO_2 from inverted or siphon-tube cylinders into the casing of a machine, two different tests were recently made by the authors. In the first test, CO_2 was discharged from inverted cylinders into the casing of a 100 Mw hydrogen-cooled generator provided with a number of observation windows in the bottom of the casing, and having several thermocouples attached to the underside of casing along its length. Six 50 lb. CO_2 cylinders were discharged in 15 minutes (a rate of 20 lb per min) causing the casing temperature at a point 10 in. from inlet pipe to fall from 70 to 32 F, and at points 30 in. and further from the inlet pipe to fall to 57 F. The atmosphere within the casing was observed to be dense with CO_2 "snow", (so dense at first that the distribution pipe could be distinguished only with difficulty, using internal mirrors with illumination), and the openings in the distribution pipe to become alternately plugged with dry ice and then free themselves. It was evident that sufficient heat could be absorbed by the CO_2 from the casing to avoid completely plugging the distribution pipe, so that the entire contents of

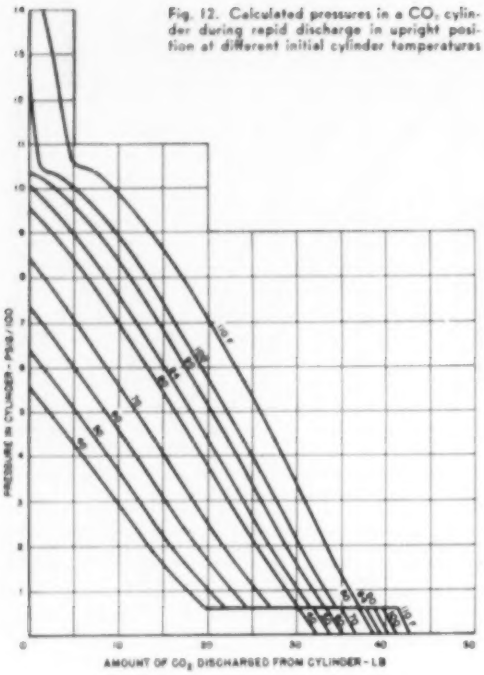

Fig. 12. Calculated pressures in a CO_2 cylinder during rapid discharge in upright position at different initial cylinder temperatures

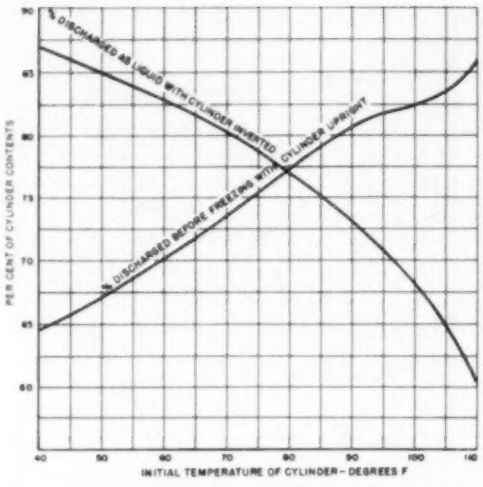
% DISCHARGED AS LIQUID WITH CYLINDER INVERTED
% DISCHARGED BEFORE FREEZING WITH CYLINDER UPRIGHT
PER CENT OF CYLINDER CONTENTS
INITIAL TEMPERATURE OF CYLINDER - DEGREES F

Fig. 13. Calculated percentage of cylinder contents discharged before freezing for cylinder discharged rapidly in upright position. Also percentage of contents discharged as liquid with cylinder inverted

six cylinders could be discharged.

The above test indicated only slight reduction in casing temperatures, except at points near the inlet pipe, with this method of purging. To determine the temperatures directly at the point of entry of the CO_2 feed pipe, a second test was made, in which themocouples were provided on the CO_2 feed pipe of a 15 Mw generator at entry to casing, and on the casing itself at this point. Six 50 lb cylinders were discharged inverted in 31 minutes (at rate of 9.85 lb per min) with the results given in Fig. 10. It is shown that the temperature of the feed pipe at entrance to casing fell from +84 F to —74 F in 5 minutes, while the temperature of the casing at this point fell to 37 F, resulting in a temperature difference of 111 F across the weld.

Using an expansion coefficient of 6.7×10^{-6} in. per in. at degrees F and a modulus of elasticity of 30×10^6 lb per in.^{2}, the above temperature difference would theoretically produce a stress of 22,400 lb per sq in. Since this value is over twice the normal working stress for a welded joint, it is evident that this method of purging, unless carefully controlled, may cause damage to a machine; hence, its use cannot be recommended.

PART II

Pressure and Temperature Variation in a CO_2 Cylinder During Rapid Discharge with No Heat Added

(A) Cylinder Discharged Upright

When a CO_2 cylinder at an initial temperature below 88 F is discharged in the upright position with no heat added, the reduction in pressure caused by loss of gas from the cylinder causes some of the liquid initially within the cylinder to evaporate. If the cylinder is discharged slowly enough—at the rate of about 7 lb per hr at room temperature—the heat of vaporization will be supplied from the room air, transmitted through the cylinder walls, and the temperature and pressure will remain constant until all the liquid has been vaporized. There will then remain in a 50 lb cylinder about 16 lb of CO_2 vapor. In the purging of hydrogen-cooled equipment with CO_2, however, the cylinders must be discharged rapidly, hence, if no heaters are supplied, the heat of vaporization must be supplied principally from the liquid CO_2, causing the temperature of the latter to drop. When the triple point of —70 F at 75 psia is reached, the latent heat of sublimation is supplied from the liquid, and discharge takes place at constant pressure and temperature until all the liquid has solidified. A small discharge continues until the sublimation point is reached, when flow ceases.

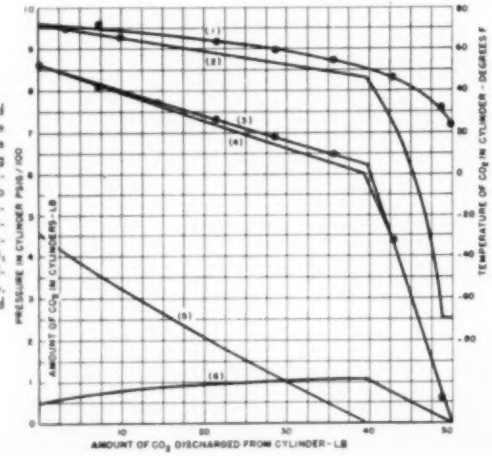
PRESSURE IN CYLINDER PSIG/100
AMOUNT OF CO_2 IN CYLINDER - LB
TEMPERATURE OF CO_2 IN CYLINDER - DEGREES F
AMOUNT OF CO_2 DISCHARGED FROM CYLINDER - LB

Fig. 14. Calculated and test values of pressure and temperature in a CO_2 cylinder during rapid discharge in inverted position with no heat added. For cylinder at 72 F initial temperature. Also calculated amounts of CO_2 liquid and vapor in cylinder during discharge. Test cylinder discharged in 7 min

Curve (1) Temperature of CO_2 in cylinder. (Test)
Curve (2) Temperature of CO_2 in cylinder. (Calculated)
Curve (3) Pressure of CO_2 in cylinder. (Test)
Curve (4) Pressure of CO_2 in cylinder. (Calculated)
Curve (5) Calculated amount of CO_2 liquid in cylinder
Curve (6) Calculated amount of CO_2 vapor in cylinder

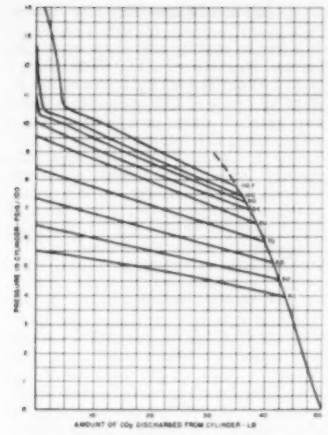

Fig. 15. Calculated pressures in a CO_2 cylinder during rapid discharge in inverted position at different initial temperatures

In Appendix I, thermodynamic relations are developed for calculating the pressure and temperature change in a standard 50 lb CO_2 cylinder during rapid discharge in the upright position. Fig. 11 shows the pressures and temperatures thus calculated, for different amounts of CO_2 discharged, for a cylinder at an initial temperature of 72 F, with test values shown for comparison. In the test 39.5 lb of CO_2 were discharged in 30 minutes, when flow ceased. The difference between test and calculated values of temperature may be attributed to the assumption, made in the calculation, of no heat absorption from the cylinder or from the room air which is strictly true only for a cylinder discharged instantaneously. In Fig. 12 is shown the calculated variation in cylinder pressure with amount of CO_2 discharged, for different values of the initial cylinder temperature. For initial temperatures above 88 F the curves have a different shape than below this value since at the higher temperatures no liquid is present, the vapor in cylinder being superheated; whereas, below this value liquid is present and the vapor is saturated.

From Fig. 12, the amounts of CO_2 that may be discharged from a 50 lb cylinder in the upright position with no heat added, before freezing occurs, are shown by the intersections of the different curves with the horizontal axis. In Fig. 13, these amounts are shown in per cent of the initial cylinder contents, for different values of initial cylinder temperature. These curves may be used for either 50, 20 or 100 lb cylinders (assuming the same initial combined density) as a means of estimating the amount of CO_2 available in a cylinder for the purging operation, for cylinders discharged rapidly in the upright position with no heat added.

(B) Cylinder Discharged Inverted

For a standard cylinder discharged in the inverted position, or for siphon-tube cylinders discharged upright, for an initial cylinder temperature below 88 F, liquid CO_2 is at first discharged. This causes the pressure in the cylinder to drop and some of the liquid CO_2 is vaporized. When the entire liquid contents are discharged the vapor contents of the cylinder will exceed the initial vapor content by the amount of liquid vaporized. Vapor will then be discharged from the cylinder until the cylinder is empty. If the cylinder is initially at a temperature above 88 F, vapor will be discharged initially until the pressure and temperature fall sufficiently until the liquid state, Fig. 1, is reached; then liquid will be discharged, and finally vapor again. In Appendix II, equations are derived for calculating the pressures and temperatures in a 50 lb cylinder during rapid discharge in the inverted position, for different initial cylinder temperatures. In Fig. 14, the calculated conditions in a cylinder during such discharge, for an initial temperature of 72 F, are shown for comparison with values of pressure and temperature ob-

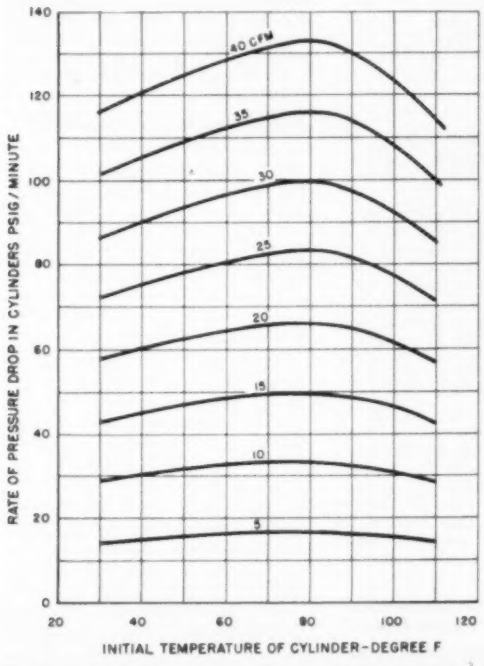

Fig. 16. Rates of cylinder pressure drop for different purging rates for cylinders discharged in upright position

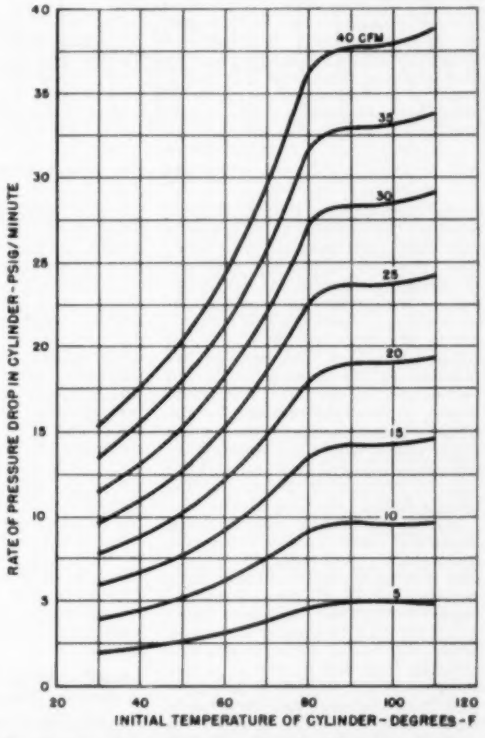

Fig. 17. Rates of cylinder pressure drop for different purging rates for cylinder discharged in inverted position

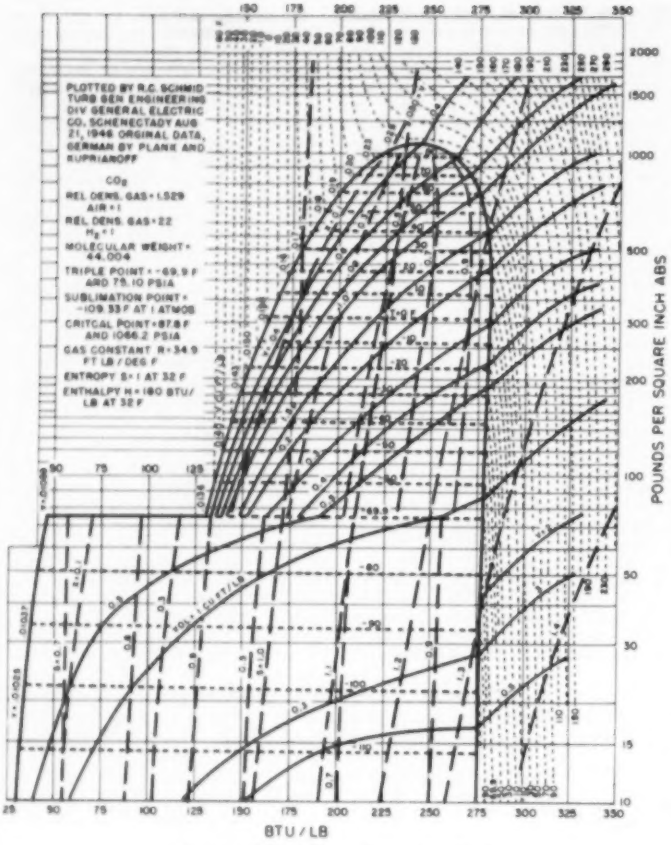
PLOTTED BY R.C. SCHMID TURB GEN ENGINEERING DIV GENERAL ELECTRIC CO. SCHENECTADY AUG 21, 1946 ORIGINAL DATA, GERMAN BY PLANK AND RUPPIANOFF
CO_2
REL DENS. GAS = 1.529 AIR = 1
REL DENS. GAS = 22 H_2 = 1
MOLECULAR WEIGHT = 44.004
TRIPLE POINT = -69.9 F AND 75.10 PSIA
SUBLIMATION POINT = -109.33 F AT 1 ATMOS
CRITCAL POINT = 87.8 F AND 1066.2 PSIA
GAS CONSTANT R = 34.9 FT LB / DEG F
ENTROPY S = 1 AT 32 F
ENTHALPY H = 180 BTU / LB AT 32 F
POUNDS PER SQUARE INCH ABS
BTU / LB

Fig. 18. Mollier diagram for carbon dioxide

tained from a test at this initial temperature, in which a 50 lb cylinder was discharged inverted in 7 minutes. The test values are observed to check closely with the calculated values, except for the vapor phase of discharge, where the test temperatures are considerably above the calculated values. This may be attributed to the assumption in the calculation, of no heat absorption, which, while fairly accurate for the liquid phase, is less accurate for the vapor phase, where the temperature difference between room air and the CO_2 in cylinder is larger, and the specific heat of the CO_2 smaller.

Fig. 14 also shows the calculated liquid and vapor contents of the cylinder during discharge, which indicate that for an initial cylinder temperature of 72 F, the amount of vapor in cylinder increases from 5.1 lb to 10.5 lb during discharge, while the liquid contents are decreasing from 44.9 lb to 0. It is also shown that the theoretical temperature in the cylinder falls to a minimum value of —70 F, instead of to —109 F as for the upright cylinder; hence for the cylinder discharged inverted with no heat added, no freezing of the cylinder contents occurs, so that the entire contents may be discharged.

In Fig. 15, the calculated pressure change in a cylinder with amount of CO_2 discharged, is shown for different values of initial cylinder temperature, for a cylinder discharged inverted with no heat added. The sections of these curves for temperatures above 88 F are identical with the curves for upright cylinders given in Fig. 12. The sections of the curves for the final phase of discharge are shown to comprise a continuous curve. From the intersections of the straight portions of the curves with the curved portions, the amount of CO_2 discharged as liquid may be determined. In Fig. 13, this amount is shown in per cent of initial cylinder contents for different initial temperatures.

Required Rates of Cylinder Pressure Drop for Different Purging Rates

It was stated earlier in this article that the rate of CO_2 admission to a machine casing should be maintained at a sufficiently low value to obtain minimum mixing of the CO_2 with the gas in casing, and thus have the lowest wastage of CO_2. With purging methods B and F, it is possible to gage the rate of CO_2 admission from the rate of drop in cylinder pressure, using the curves of Fig. 12 and 15 as a basis. From the approximately straight portions of these curves, corresponding to the saturated vapor phase for Fig. 12, and the liquid phase for Fig. 15, the rate of pressure drop per pound of CO_2 discharged, at different initial cylinder temperatures, may be determined. Multiplying this value by the purging rate in cfm, times the density of CO_2 at the initial cylinder temperature, gives the cylinder pressure drop in psi per minute at the different purging rates, the latter being calculated for convenience, at the initial cylinder temperature. Note: (cu ft per min) $\times$ (lb per cu ft) $\times$ (psi per lb) = psi per min. In Fig. 16 and 17 are given curves of rate of cylinder pressure drop at different purging rates, for different initial cylinder temperatures, calculated in this manner from the curves of Fig. 12 and 15.

To illustrate the use of the curves of Fig. 16 and 17, assume a 5-cylinder CO_2 manifold, with cylinders at an initial temperature of 70 F, and let a purging rate of 50 cfm be chosen, giving a rate per cylinder of 10 cfm. For cylinders discharged upright, with no heat added, Fig. 16 shows that the initial rate of cylinder pressure drop should be about 33 psi per min; while for cylinders discharged inverted, Fig. 17 indicates that the initial rate of pressure drop in a cylinder should be about 7.5 psi per min.

Design of Heaters for Use with CO_2 Purging Systems

With purging systems C and F (Fig. 3), heaters for the CO_2 are required; in method C, a heater for the cylinder water-bath, and one in the line to control valve, are used; while in method F, a vaporizer for

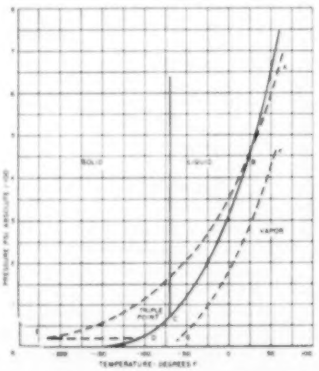

Fig. 19. Equilibrium diagram of CO_2 showing paths of expansion

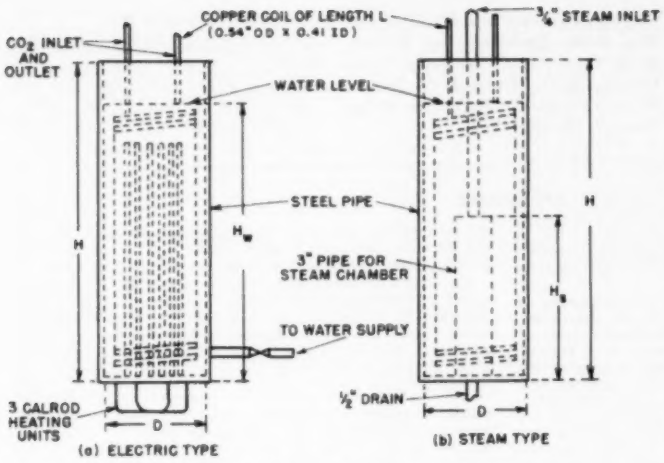

Fig. 20. Design of CO_2 heaters for use with purging systems

Heater Specifications for purging rate of 480 lb per hr (70 cfm at 70 F)

	As Superheater	As Vaporizer
H inches	24	30
H_w inches	20	26
H_s inches	6	15
D inches	8	10
L feet	25	45
Heaters	3—2 KW Units or Steam at 250 psig	3—6 KW Units or Steam at 250 psig

the liquid CO_2 is required. In the following, data for calculating the requirements of such heaters are given, together with design data on simple immersion-type heaters. To illustrate the calculation of the heater requirements, a purging rate of 70 cfm, for room temperature of 70 F, will be assumed, and it will be required to determine the requirements of heaters, using both methods C and F, which will permit CO_2 gas to be discharged at 70 F and atmospheric pressure to the machine casing.

Considering method C first, the flow of CO_2 from cylinders is $70 \times 0.115 \times 60 = 480$ lb per hr. The heaters for cylinder bath must supply the heat of vaporization, which from Fig. 18 at 70 F is $270 - 208 = 62$ Btu per lb, hence for the required discharge rate, during vaporization of the 45 lb of liquid in each cylinder, $62 \times 480 = 30{,}000$ Btu per hr, or 8.8 kw must be supplied. The superheater ahead of the control valve must then heat the CO_2 discharged from the cylinders to a sufficiently high temperature at the discharge pressure of 840 psia, to permit discharge to atmospheric pressure at 70 F. From Fig. 18 the enthalpy for this condition is 312 Btu per lb, hence the superheater must add $312 - 270 = 42$ Btu per lb, or $42 \times 480 = 20{,}000$ Btu per hr, or 5.9 kw.

With method F, the vaporizer must supply both the heat of vaporization and the superheat. Referring to Fig. 15, for an initial cylinder temperature of 70 F, the average pressure in an inverted cylinder during the liquid phase of discharge is about 740 psia. Referring to Fig. 18, the heat of vaporization at this pressure is $275 - 200 = 75$ Btu per lb. Also, to superheat the discharged vapor sufficiently to permit discharge at 70 F and 14.7 psia, an input of $312 - 275 = 37$ Btu per lb is required; hence the required capacity of vaporizer, for the liquid phase of discharge (which is the maximum requirement) is $(75 + 37) \times 480 = 48{,}000$ Btu per hr, or 15.8 kw.

In Fig. 20 are shown two different designs of CO_2 heater of the immersion type, which are easily made, and which may be used with purging systems of either of the above types. A copper heating coil of 0.54 in. od with 0.062 in. wall is used in this heater. Assuming the power requirements calculated in the above example, the superheater for method C would require a coil length of about 25 ft, wound in a helix of 6.5 in. mean dia. and a water container of 8 in. id × 24 in. high. Three 2 kw heaters arranged as in Fig. 20 (a) would approximately meet the power requirements, including radiation and convection losses. For the vaporizer used in method F, a coil length of about 45 ft, with helix dia. of 8.5 in. (mean), with container of 10 in. id × 30 in. high, are suggested. Three 6 kw heaters would provide ample power to meet the calculated requirements.

If a supply of low-pressure steam is available, the arrangement shown in Fig. 20 (b) might be used, in which the same heating coil is provided as with the electric heater, but using a steam cylinder for the water heater. For steam at 250 psig, calculations and tests indicate that a cylinder of 3 in. id × 6 in. high would be adequate for the superheater required with method C, while a cylinder 3 in. id × 15 in. high would be required for the vaporizer used with method F.

A heater of any convenient type may be used for the cylinder water bath in method C. However, care must be taken that the temperature of the bath does not exceed 125 F, otherwise sufficient pressure may be obtained in the cylinders to rupture the relief discs in the cylinder valves. (These are set to relieve at about 2000 psig.)

Summary

Of the various methods used in purging hydrogen-cooled machinery, the method using inverted or siphon-tube cylinders, with a vaporizer, is the most rapid and efficient, although requiring more equipment than other methods. Purging with this cylinder arrangement, without a vaporizer, which is sometimes done, may cause excessive chilling of the machine casing, producing harmful stresses. With cylinders discharged rapidly in the upright position, about 25 per cent of the cylinder contents are made unavailable through freezing. With inverted or siphon-tube cylinders, no freezing occurs. The rate of pressure drop in a cylinder during discharge, with no heat added, may be used as a guide to control the purging rate, and thus obtain less wastage of CO_2.

Acknowledgments

In the preparation of this article numerous individuals and companies have given assistance through suggestions and contributions, while others have assisted in the design of the equipment and in making the

Table I showing CO_2 temperatures after rapid expansion in factory tests, inverted cylinders and vaporizer, see Fig. 7-B

Test No.	Lb CO_2 Disch.	Time Min.	Lb per Min.	CFM at 70 F & Atm. Pres.	Length of Cu Tubing (0.4 in. id)	Av. Temp. Water Bath F	Btu	Heat Input to Water Bath kwh	Btu per lb CO_2 Disch.	Min. Temp. of Gas Disch. from Control Valve F
1	200	23	8.7	76	44 ft	150	13,800	4	69	-230
2	200	19	10.5	91	100 ft	205	23,300	6.8	116.5	113
3	200	18	11.1	97	75 ft	183	24,350	7.1	121.8	91

tests described. Some of these, to whom the authors are indebted, are: Mr. F. M. Porter of the American Gas & Electric Service Corp., Mr. A. J. Granata of the Pure Carbonic Co., Mr. F. B. Hunt, Liquid Carbonic Co., The Cardox Corp., Chicago, and Mrs. B. O. Buckland, and Messrs. A. K. Frank, J. K. Salisbury, R. G. Rhudy, A. O. White, F. T. Horan, D. L. Hall and D. J. Dieters of the General Electric Co.

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APPENDICES

APPENDIX I

Calculation of Pressures and Temperatures Obtained in a CO_2 Cylinder During Rapid Discharge in Upright Position with no Heat Added

This calculation is a step-by-step process, consisting in taking small decrements of temperature change during the period of discharge of a CO_2 cylinder, and from a table of properties of saturated CO_2 and the Mollier chart, Fig. 18, determining the heat content, pressure and density of the liquid and gaseous CO_2 at beginning and end of each temperature interval; then using these quantities to determine the loss of weight of CO_2 from the cylinder in the interval, required to satisfy the thermodynamic relations. In this discussion, the subscripts 1 and 2 will denote the beginning and end, respectively, of a temperature interval; for example, T_1 and T_2 will represent the temperatures of CO_2 in the cylinder at the beginning and end of a given interval, in degrees F. Other symbols used are as follows:

M = weight of CO_2 in cylinder, lbs. $\triangle M = M_1 - M_2$
P = pressure in cylinder, psia. $\triangle P = P_1 - P_2$
P_a = atmospheric pressure, psia (14.7 assumed)
H = total heat (enthalpy) of CO_2, Btu per lb
H_f = total heat (enthalpy) of fluid Btu per lb
H_g = total heat (enthalpy) of vapor Btu per lb
u = intrinsic energy of CO_2 Btu per lb
u_f = intrinsic energy of fluid Btu per lb
u_g = intrinsic energy of vapor Btu per lb
L_v = Latent heat of vaporization Btu per lb
v = specific volume of mixture, cu ft per lb
v_f = specific volume of fluid, cu ft per lb
v_g = specific volume of vapor, cu ft per lb
V_c = volume of cylinder, cu ft
x = quality of mixture, per unit

It will be assumed that the cylinder discharges directly to atmosphere, which is approximately true in the purging operation, where the pressure in casing is held at 2 or 3 psig and the pressure drop in the CO_2 feed line is small. For a cylinder discharged in either the upright or inverted position, with no heat added, the general relation which exists during discharge is:

Decrease in total energy in cylinder = loss in intrinsic energy + external work done.

For a cylinder discharged in the upright position, this relation is expressed by the equation:

$$M_1H_1 - M_2H_2 = 0.5\ \triangle M\ (u_{f1} + u_{g2}) + \triangle M(V_{f1} + V_{g2})\ (P_1 - P_a - 0.5\triangle P) \div 10.8 \quad (1)$$

Considering first an initial cylinder temperature below 88 F, so that both liquid and vapor are present, the various quantities in eq. (1) are defined as follows:

$$H_1 = H_{f1} + x_1L_{v1} \quad (2); \qquad H_2 = H_{f2} + x_1L_{v2} \quad (3)$$

$$u_{g1} = H_{g1} - P_1v_{g1} \div 5.4 \quad (4); \quad u_{g2} = H_{g2} - P_2V_{g2} \div 5.4 \quad (5)$$

where $x_1 = (V - V_{f1}) \div F = (V_c \div M - V_{f1}) \div F \quad (6)$

and $F = V_{g1} - V_{f1} \quad (7)$

(Note: $F_1 = V_{g1} - V_{f1}$, $F_2 = V_{g2} - V_{f2}$)

Letting $M_2 = M_1 - \triangle M$ in eq. (1) and solving for $\triangle M$ gives $\triangle M = A \div B \quad (8)$; where $A = M_1\ (H_1 - H_{f1}) + (M_1V_{f2} - V_c)\ L_{v2} \div F_2 \quad (9)$

and $B = 0.5\ (H_{g1} + H_{g2}) - H_{f2} + L_{v2}V_{f2} \div F_2 + \{\triangle PV_{g2} - (V_{g1} + V_{g2}) \times (P_2 + 0.5\ \triangle P)\} \div 10.8 \quad (10)$

For a full cylinder, at temperature T_1, the quality

$$x_1 = \frac{V_c \div M - V_{f1}}{V_{g1} - V_{f1}}$$

(For a 50 lb cylinder at $T_1 = 70$ F, $M_1 = 50$, $x_1 = 0.1$) Reference to tables of saturated CO_2 permits the calculation of H_1 and F_1 from eqs. (2) and (7). For the first temperature interval, letting for example ($T_1 = 70$ $T_2 = 66$), the values of A and B are calculated from eqs. (9) and (10), using the values of H_{f2}, H_{g2}, L_{v2}, etc. determined for $T_2 = 66$ F. The loss in cylinder contents $\triangle M$ for the first temperature interval is then calculated from eq. (8) and the value of x_2 from eq. (6). These values are then used to obtain M_2, H_2, etc. for the second interval, and so on. The calculated curves in Figs. 11 and 12 were obtained in this manner, for values of initial cylinder temperature below 88 F.

For initial cylinder temperatures above 88 F, since no liquid is then present, and the gas is superheated, the values of H_1 and H_2 in eq. (1) must be determined from the Mollier chart, Fig. 18, and u_{g1} and u_{g2} will be given by the equations:

$u_{g1} = H_1 - P_1V_c \div 5.4\ M_1$ (11); $u_{g2} = H_2 - P_2V_c \div 5.4\ M_2$ (12)

Also, since $M_1 = V_c \div V_1$, $M_2 = V_c \div V_2 = M_1 - \triangle M$;

$$\triangle M = V_c\ (V_2 - V_1) \div V_1V_2 \quad (13)$$

Substituting the above relations in eq. (1) gives the equation for initial cylinder temperatures above 88 F:

$$M_1\ (H_1 - H_2) = \triangle M\ [.5\ (H_1 - H_2) + \{V_2\ (.5\ \triangle P - P_a) - V_1\ (.5\ \triangle P + P_a)\} \div 10.8] \quad (14)$$

Eq. (14) is used to obtain the pressure and temperature conditions in the cylinder as follows: For a given initial cylinder temperature T_1, the values of P_1 and H_1 are read from Fig. 18 at the intersection of the curves for $T = T_1$ and $V_1 = V_c \div M_1$. Next assuming a slightly lower temperature, above 88 F, values of V_2 and H_2 are selected from the curve for $T = T_2$ which, when substituted in eq. (14), make both sides of the equation equal. (This occurs for H_2 practically equal to H_1 in all cases). This equality determines $\triangle M$ and M_2, the latter quantity becoming M_1 for the second temperature interval, and so on. This method was employed in determining the curves in Fig. 12 and 15, for temperatures of 90 F and above.

APPENDIX II

Calculation of Pressures and Temperatures Obtained in a CO_2 Cylinder During Rapid Discharge in Inverted Position with no Heat Added

As mentioned in the body of this article, the discharge of a CO_2 cylinder in the inverted position may involve two or three phases depending on the initial cylinder temperature. For initial temperatures above 88 F, the equations for calculating the pressures and temperatures in the cylinder for the first vapor phase, are identical with those derived in Appendix I for discharge of an upright cylinder at initial temperatures above 88 F. For the liquid phase, however, the equations are different, eq. (1) being written as follows:

$$M_1H_1 - M_2H_2 = 0.5\ \triangle M\ (u_{f1} + u_{f2}) + \triangle M\ (V_{f1} + V_{f2})\ (P_1 - P_a - .5\ \triangle P) \div 10.8 \quad (15)$$

where $u_{f1} = H_{f1} - P_1V_{f1} \div 5.4 \quad (16)$

$u_{f2} = H_{f2} - P_2V_{f2} \div 5.4 \quad (17)$

and H_1, H_2, x and F are defined by eqs. (2), (3), (6) and (7), App. I, respectively.

Substituting these relations in eq. (15) and solving for $\triangle M$ gives $\triangle M = A \div C \quad (18)$

where $A = M_1\ (H_1 - H_{f2}) + (M_1V_{f2} - V_c)\ L_{v2} \div F_2$ (9), from App. I, and $C = 0.5\ (H_{f1} - H_{f2}) + L_{v2}V_{f2} \div F_2 + [\triangle PV_{f2} - (V_{f1} + V_{f2})\ (P_2 + .5\ \triangle P)] \div 10.8 \quad (19)$

Eq. (18) is used in calculating the pressures and temperatures for the inverted cylinder for the liquid phase of discharge, in the same manner as eq. (8) was used for the upright cylinder. The step-by-step calculation is repeated until a value of $x_2 = 1.0$ is reached, indicating the end of the liquid phase. The curves of cylinder pressure vs. amount of CO_2 discharged, obtained by the use of eq. (18) are approximately straight lines, as shown in Fig. 14 and 15.

For the final phase, a mixture of liquid and vapor is discharged (theoretically, although actually it is practically all vapor), so that eq. (1) becomes:

$$M_1H_1 - M_2H_2 = .5\ \triangle M\ (u_1 + u_2) + M\ (V_1 + V_2)\ (P_1 - P_2 - .5\ \triangle P) \div 10.8 \quad (20)$$

where $u_1 = H_1 - P_1V_c \div 5.4\ M_1 \quad (21)$

$u_2 = H_2 - P_2V_c \div 5.4\ M_2 \quad (22)$

and H_1, H_2, x and F are defined by eqs. (2), (3), (6) and (7), App. I, respectively.

Substituting the above relations in eq. (20) and solving for ΔM gives:

$$\Delta M = (\psi + \sqrt{\psi 2 + 4\phi\gamma}) \div 2\phi \quad (23)$$

where $\phi = 0.5R + V_s\ (P_s + 5\ \Delta P) \div 10.8M_1$ (24)

$$\psi = -1.5M_1R + V_s\ (P_s \div 5.4 + L_{s3} \div 2F_2) \quad (25)$$

$$\gamma = M_1\ (M_1R - L_{s3}V_s \div F_2) \quad (26)$$

and $R = H_1 - H_{t2} + L_{w2}V_{t2} \div F_2$ (27)

The pressure curves for the final phase are calculated from eq. (23) in the same manner as those for the liquid phase were calculated from eq. (18), and are shown in Fig. 14 and 15 for different initial cylinder temperatures, as a single curve.

APPENDIX III

An explanation of the extremely low temperatures obtained in a factory test with inverted cylinders

In Table I and Fig. 7b are shown temperatures of CO_2 after rapid expansion as obtained in factory tests in which inverted cylinders were discharged thru a vaporizer and control valve to atmosphere. Due to insufficient heat input to vaporizer in Test No. 1, temperatures on discharge side of control valve as low as -230 F were obtained. In seeking an explanation for such low temperatures, the hypothesis of equilibrium expansion was first considered. However, a change of state with equilibrium maintained is an ideal state and never quite realized. The greater the disturbance the greater is the departure from equilibrium. In the case of expansion of CO_2 from 1000 to 5 psig in the time and space required by the conditions of the tests, supersonic flow exists, hence a wide divergence from the equilibrium expansion would be expected. Perfect adiabatic expansion to 20 psig, referring to Fig. 18 should give a temperature of -102 F or above under equilibrium conditions, instead of -230 F as measured. This under-cooling may be attributed to supersaturation, a phenomenon that may occur if the flow of gaseous CO_2 thru the expansion valve initially contains liquid droplets, is saturated, or is only slightly superheated.

Calculations of the conditions of flow thru the valve, taking account of supersaturation, would be quite difficult. A few deductions from the test data may be made, however. Consider, for example, the data from test 1 at 6 min. For this test point, liquid in cylinder at 66 F and 705 psig expanded thru the vaporizer and control valve to -219 F at 20 psig. This expansion is represented in the equilibrium diagram Fig. 20 by Curve ABE. The path ABCD represents frictionless adiabatic expansion under equilibrium conditions. Segment AB represents the part of the expansion in the region of superheat. Point B is on the saturated vapor line and further expansion under equilibrium conditions will follow the path BCD and will require the condensation of some of the vapor. Condensation requires time and is promoted by the presence of nuclei such as particles of dust. These conditions are not present in the above case and the change of state is so rapid that the expansion moves along a path continuous with AB. The carbon dioxide is now supersaturated or under cooled. The test data indicate that the final temperature reaches the neighborhood of -222 F, represented by E in the diagram. The system immediately strives to attain the equilibrium state represented by point D for a pressure of 20 psig. By solidification of part of the vapor, the system is warmed until the equilibrium temperature is reached.

It is evident that supersaturation is undesirable in a system similar to that of Test 1 as the formation of solid CO_2 will tend to clog the discharge chamber and impede the flow. This may be avoided by superheating the gas sufficiently before expansion. Referring to the data of test No. 1 at 18 minutes, the liquid in cylinder was at 56 F and 465 psig, and expanded on discharge to -60 F at 17 psig. This expansion is represented on the equilibrium diagram Fig. 20 by Curve FG. In this case, the CO_2 was superheated sufficiently to allow the entire expansion to take place within the region of superheat.

LETTERS
TO THE EDITORS

(Continued from page 53)

feedwater, that water walls lessened slag formation, and that coal or coal dust scattered over floors and washed down sewers contained Btu's. And above all that, men released from manual drudgery were enabled to take much better care of their valuable equipment than formerly.

More and more plants became equipped with automatic machinery, draft controls, feedwater regulators, suction ash conveyors. It soon became apparent that the power plant was a presentable part of the institution and could be viewed with pride. Still those crowded and inconvenient premises prevented what we call good housekeeping. There was not a room for oil, grease, paint, polish, cleaning materials. There was not in some cases a toilet and washroom, no lockers for workers' street or working clothes and the crew had to hang their overalls in some corner or ramshackle cupboard with tools or stores. Usually the staff members had their own personal tools for use on shifts, these kept in a locked box somewhere round the boiler house for use on the owner's shift.

Happy to relate these conditions have appreciably lessened during recent years. In newer plants they have disappeared. Pre-construction planning with a lot more space allowance for efficient operation of steam plant and auxiliaries, men's shower, locker and washrooms, store rooms for tools and such, has been a great boon to engineers and consequently to their plants. Where there is a work room with bench, vise, pipevise, drill stand and a few accessories you'd be surprised how many odd jobs are done right there without the delay or inconvenience of getting a work order, material, and possibly outside help. Traps on many machines need periodic overhauling, valves ditto, governors, controls get out of order. Wherever these can be removed to a work room it is usually done as a stitch in time, moreover the educational point in dismounting, reassembling and treatment gives the operator a much better idea of how it works and why. A good big work bench with a substantial lock drawer for each shift engineer will pay dividends. Most concerns are loath to furnish full sets of tools because units so often turn up missing strange to say, so the alternative is to let each man furnish and use his own small tools with a secure place to keep them, keys in his custody. This plan seems to work fairly well.

Floors are receiving more attention these days, rough concrete is very difficult to keep clean unless given a couple of seal coats and then painted often. If this is done a hair broom or mop once over periodically will produce good results. The same applies to boiler tops, breeching, mezzanine, railings, stairs. Paint and paint again. Staff soon gets the habit of running up and down railing with a rag or waste if there is a hard glass surface there to which dust will not stick. Boiler tops and breechings will require many coats before wet cloths or water can be used to clean them, lagging of pipes comes in the same category. I have seen pipes covered with two inch magnesium and cotton, painted semi-annually until sufficient surface exists to carry a big man without cracking (the covering of course).

A good substantial vacuum cleaner certainly pays it way, should have a quarter horse motor and about twelve accessories, be portable enough to lug upstairs to boiler cat walks, coal pent house or any place dust collects. Plenty of extensions should be furnished to reach window ledges, breechings, lamp shades, etc. A couple of bananas large and small will slide along big piping and remove dust like sixty, followed by a wipe. Narrow nozzle for bases in behind bolts, for crannies or cracks hard to get at. These machines will pick up anything that can be handled by an ordinary burglar; a pair of No. 9 shoes was found in the tank once, though history doesn't relate what happened to the man wearing them and there was no odor of sausage. Years ago we rigged up a steam jet suction discharging into ashpit and ran 2 inch pipe up the boiler columns, teed and plugged at short intervals for hitching a hose. But we couldn't get hose of sufficient size and strength to handle things right and the apparatus was regretfully discarded. I still think if it had discharged into a wet condensing

chamber and wire reinforced hose had been available the darned thing would have worked.

Incinerators are a headache, emptied food cans must be burried before transfer to dump areas, garbage almost has to be spread out and looked over before burning for the dozens of lighters, wrist watches and gadgets that occasionally turn up in garbage cans. Again seal and paint those floors. Steam at fairly good pressure is the best sterilizer for cans and floors extant, but floors must have good coating to stand it. Brick or concrete window sills also indicate a good heavy gloss paint and can then be dusted as easily as your Heintzman. Please don't run off and decide that this article is just free advertising for some paint company. I'm just a paint fan of long experience and wind. Try it, you fellows.

Sunnybrook Hospital, Toronto, Ont.

A. E. RICHARDS

FOR THE DIESEL OPERATOR

How to Select the Correct Diesel Starting Battery

Characteristic curves prepared by Gould Storage Battery Laboratories enable one to select battery with the proper number of cells for varying conditions and for different engines

FOR MANY YEARS the battery industry has supplied users of Diesel starting batteries with curves and charts designed to help select the correct battery for the job. It is felt, however, that many purchasers do not apply this helpful information which is available to them. For this reason, the Laboratories of the Gould Storage Battery Corp. have prepared the accompanying typical discharge characteristic curves and explain how to use them.

The number of lead-acid cells required to operate the motor needed to start a Diesel engine is determined by the designer of the Diesel engine. If, for example, the starting motor of a locomotive Diesel is designed about a 64-v circuit, a 32-cell lead-acid battery is required, each lead-acid cell being rated at 2 v.

But there is a lot more to it than that. The three principal considerntions involved are: (1) the temperature at which the battery is to be operated, (2) the breakaway voltage required, and (3) the final voltage to which the battery can be discharged and still start the engine.

Knowing these factors, (they depend on the design of the engine and starting motor) the discharge characteristic curves are used to select the correct battery. The graphs are prepared on a per cell basis since different Diesel engines require batteries having different numbers of cells. The abscissa is marked off in amperes per positive plate. The reason for this will become apparent as the use of the curves is explained.

Typical curves are shown in Figs. 1 and 2. If an initial breakaway voltage of 1.2 v per cell is required, one would follow this coordinate out to the "initial volts" curve and then drop down to the "amperes per positive plate" ordinate. Knowing the total current required, say 2000 amp for breakaway, the number of positive plates can be determined, in this case $\frac{2000}{180} = 11.1$, or 12 plates.

For each positive plate there is an equal number, plus one, of negative plates. So the battery required would be a 25-plate battery. Battery plates are connected in parallel so the more plates, the more current available. Incidentally, this battery would be discharged to a final voltage of 0.70 v per cell in 2¼ minutes.

From Fig. 2, if the battery was to be used in a northern climate, a 33-plate battery would be required.

Sometimes the selection of the battery depends on the final voltage, i.e., the voltage to which the battery can be discharged and still start the engine. This value, again, is determined by the design of the starting circuit. For example, if the final voltage of a battery required to deliver 1200 amp is not to be below 1.00 v per cell at 77 F, a 21-plate battery would be required. This battery would have an initial voltage of 1.40 v per cell and would discharge to a final voltage of 1.00 v in 4 minutes. At 32 F a 31-plate battery would be required.

If the battery indicated does not fit the space limitations, then the same procedure would be followed using discharge characteristic curves of other battery models until a battery fitting the space limitations is met. Because of the size and weight, incidentally, batteries are assembled in units of three or four cells. This not only makes it easier to handle the batteries in confined spaces, but also makes it possible to stow sections of the battery in several locations.

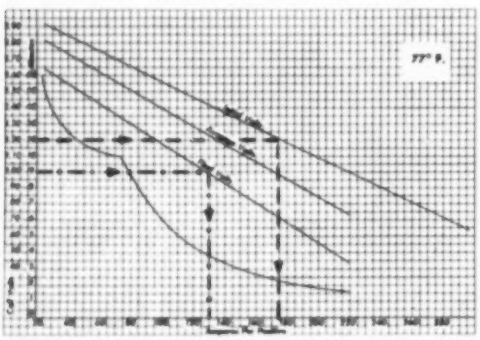


Fig. 1. Curves for use in climates where the average temperature is 70 degrees

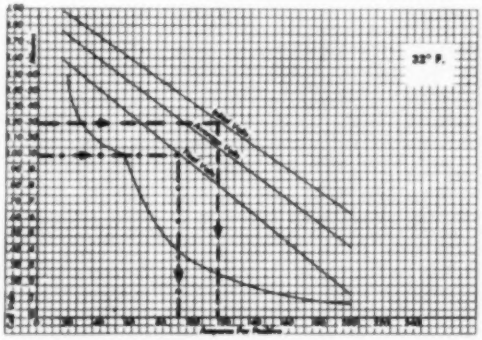


Fig. 2. Curves for use in Northern climates where the temperature goes down to 32 degrees

GAS TURBINES

Annapolis Gas Turbine Operates Successfully at 1500 F

SUCCESSFUL OPERATION with inlet gas temperatures of 1,500 F has been accomplished in tests on the Allis-Chalmers gas turbine at Annapolis, the U. S. Navy and the Allis-Chalmers Mfg. Co. have revealed. This turbine unit is the first to be designed for long-time service with operating temperatures as high as 1,500 F, according to Allis-Chalmers engineers.

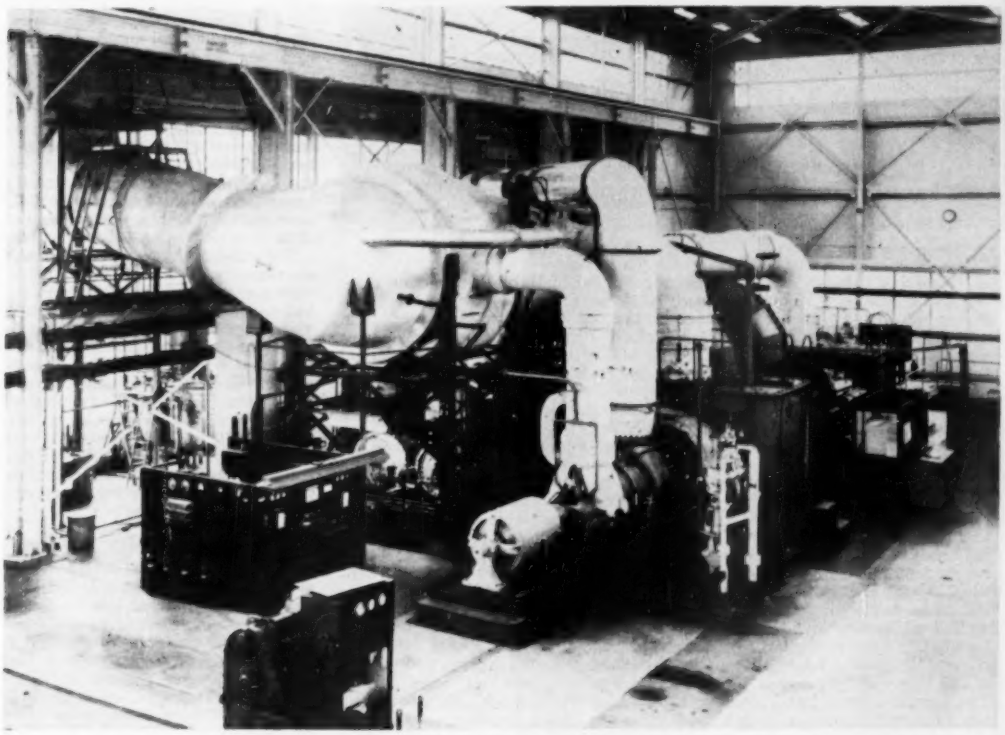
Installed at the U. S. Naval Engineering Experiment Station in 1944, the elements of this gas turbine unit have since been operated in more than 3,000 turbine-hours of rigorous testing, and have been started and stopped more than 400 times. Successful operation of the unit at 1,350 F was announced in 1946, (see *Power Plant Engineering*, May, 1946) and subsequent tests have included operation for some length of time at temperatures ranging up to 1,524 F. this latest announcement reveals.

The performance of the test unit, which includes two gas turbines, an axial flow compressor, a regenerator, and auxiliary equipment, has been very satisfactory thus far, the operators report. Despite the high temperatures at which the unit has been operated, there have been no failures of blading in the high temperature turbine zones. Frequent inspections have revealed no indications that the unit will not have a satisfactorily long operating life.

Heretofore, temperatures as high as 1,500 F have only been achieved in short time tests of turbines operating above their normal design temperatures, or in short-life-cycle machines such as aircraft jet engines, in which the advantages of extremely high power concentration in a small volumetric space and very low specific weight offset the reduced operating life resulting from the high initial gas temperatures applied to light-weight machines.

Among the many design innovations being tested in this installation are various methods of applying cooling air whereby high temperature parts may be cooled to protect them against undue weakening effects of extremely high temperatures. Other design features of the turbines have demonstrated their soundness in enabling the unit to successfully withstand abnormal operating conditions which have occurred during some of the tests.

Probably the greatest significance in the successful operation of this unit at a temperature as high as 1,500 lies in the importance of high temperature operation in increasing gas turbine thermal efficiency. While Allis-Chalmers spokesmen are careful to emphasize the experimental nature of the Annapolis unit, it is expected that the design, materials application, and operation lessons learned from the continuing testing of this unit will lead directly to improved reliabiliy and efficiency of commercial units, thus helping to bring the gas turbine nearer to full realization of the promise it shows for application in many marine propulsion and power generation fields.



General view of Allis-Chalmers gas turbine unit installed at U. S. Engineering Experiment Station, Annapolis, Md.

New Boiler

Fig. 1. North East Elevation of the Boiler Plant at Kutztown State Teachers College. The old 100 ft. stack was increased in height to 130 ft.

FIGURE 1, shown above, illustrates the new compact steam boiler plant which has recently been erected at the State Teachers College, Kutztown, Pennsylvania, to furnish that institution with heating and process steam for use throughout the school. This institution began its history as a place of education and training for teachers 83 years ago. Formerly it was known as the Keystone Normal School but in 1926 it was raised to the rank of a State Teachers College. The enrollment at this school has about quadrupled in the past five years, resulting in heavy demands upon all school facilities. About 1921, a boiler plant installation was made to serve the six main buildings of the school. This installation consisted of three Harrisburg Star water tube boilers, each of 250 bhp and operated at 100 psig. The furnaces were hand fired with No. 1 buckwheat anthracite coal, and all coal and ash were handled manually. It became apparent to the Department of Public Instruction during the middle 1940's that the operation of this plant involved high maintenance charges and low boiler availability. Further, the manual coal and ash handling work entailed considerable labor expense and difficulty was encountered in retaining personnel for this work.

The Commonwealth was forced to the conclusion that the existing boiler plant was obsolete. Men and materials for plant expansion were becoming available since the end of the war and it was deemed economical to replace the existing facilities with modern labor saving efficient equipment. Gilbert Associates, Inc., of Reading, Pa., was retained to make a preliminary study of the requirements at the school for heating and process purposes and to prepare preliminary estimates of the cost of such work. Subsequently, the consulting engineers were commissioned to prepare detailed engineering studies of the project and make layouts of the various equipment arrangements. Limitations existed since the expressed policy of the Commonwealth was to make the fullest possible use of all existing structures and to maintain one boiler in service at all times throughout the construction period. The use of the original boiler house site obviated extensive changes in pipe lines which emanated from the existing boiler house. Ultimately, a practical layout, satisfactory to all interested parties, was reached. Specifications were then prepared for the information of the general contractors who were invited to submit sealed proposals.

Corbit's Inc. of Reading, Pennsylvania was the successful low bidder and, accordingly, was awarded the contract for this project on December 4, 1947. Preliminary work by the contractor was immediately begun and actual work in the field commenced during the spring of 1948.

The existing boiler room was approximately 60 ft by 45 ft in plan, with a clear height of 22 ft from the boiler room floor to the roof steel. The equipment finally selected fitted well into the plan dimensions of the structure but its height was inadequate. It became necessary to increase the height of the roof above the boiler room proper by a distance of 14 ft, and above the coal bunkers 21 ft. This offset roof line and the associated coal handling equipment shown in Fig. 1 clearly illustrate this change.

Anthracite Burned on Traveling Grates

The continued relatively low cost of fine anthracite coal, coupled with its wide availability in eastern Pennsylvania, demonstrated to the engineers of the Commonwealth that it would be economical to fire a fuel of this type. Accordingly, the general specifications called for traveling grate stokers designed to burn No. 3 anthracite. Similarly, low head boiler construction, or its equivalent,

Plant for Kutztown State Teachers College

A detailed description of the factors involved in the expansion and rehabilitation of the boiler plant at the State Teachers College at Kutztown, Pennsylvania. Three 15,000 lb per hr, anthracite fired boilers, replace old Harrisburg Star Boilers. Old building structure was retained but architectural features modernized

By G. L. YEAKEL,
Gilbert Associates, Inc., Reading, Pa.

was specified to minimize building height. The general contractor and the consulting engineers found that the Combustion Engineering-Superheater, Inc. Coxe traveling grate stokers and Keeler CP boilers were admirably suited to the conditions encountered. The dimensions of these principal pieces of equipment and their auxiliaries fixed the space requirements and layout studies revealed that adequate floor space was available and the increased building height was accordingly fixed. This boiler-stoker combination has been accepted for a number of similar Commonwealth projects which are being constructed in eastern Pennsylvania.

There was in existence at the inception of this project a brick stack extending 100 feet above the boiler room floor. Examination of the stack revealed that it was in generally good condition and that it had many more years of service life. Study of the structure showed that without foundation changes it would be possible to increase the height to 130 ft above the boiler room floor and thereby secure sufficient natural draft for the maximum loads visualized. This stack was originally designed and furnished by the American Chimney Corp., which organization rehabilitated and extended it. The reconstructed stack is prominently displayed in Fig. 1.

All coal consumed at the boiler plant is shipped by truck. An existing ramp has been used and a pocket provided in the flat area at the top of the ramp, into which coal is dumped. The fuel is chuted from this small hopper into a chain, centrifugal type of bucket elevator which has a capacity of 40 tons per hr. Coal may be chuted to any one of the three boiler bunkers from the top of the elevator structure by means of flapper gates which are chain operated from the boiler room operating floor. Coal may also be stocked out by dumping from the delivery trucks into the storage area, which accommodates approximately 300 tons. This fuel is reclaimed by means of a portable conveyor which in turn discharges to the elevator feeder pocket. This installation provides a considerable element of flexibility with regard to the times of receiving and unloading coal, thereby permitting the most highly advantageous scheduling of fuel shipments.

Each of the boilers is served by an individual bunker of 35 tons capacity. The inclined sides of the bunkers are lined with tile to minimize abrasion and corrosion although the coal received is low in sulphur content. The internal vertical sides of these bunkers are lined with bitumastic enamel for similar protective purposes. Each bunker contains approximately three days supply of coal for full load boiler operation. This operating situation is not anticipated but the bunker capacities are such as to render the operation of the coal handling equipment over weekends superfluous. Coal passes by gravity through 12 in. diameter downtake chutes to the individual stoker hoppers.

The coal is fed from these hoppers to the Coxe stokers, fuel bed thickness being regulated by an inlet gate. The rate of fuel firing is varied by changing the stoker speed, each stoker being equipped with an individual Reeves variable speed drive and is regulated by combustion control.

The three new boilers were manufactured by the E. Keeler Co. and

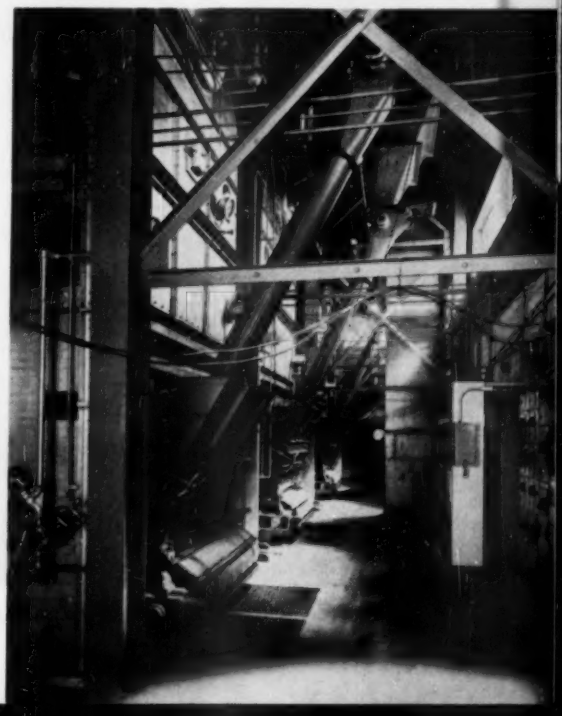


Fig. 2. A view of the boiler firing aisle. The three 15,000 lb per hr boilers are fired by three Coxe traveling grate stokers burning anthracite

are of the CP design. This type of boiler offers a considerable amount of water wall heating surface and is a compact, efficient steam generator. These boilers are rated at 15,000 lb per hr each of 100 psig saturated steam at 74 per cent efficiency. They may be operated at rates as high as 20,000 lb per hr for peaks of a few hours duration. There are two drums each in these bent tube water tube boilers, a long longitudinal upper drum which serves as the feedwater and steam drum, and a shorter lower mud drum also longitudinally aligned. There are three gas passes leaving the furnace and defined by vertical baffles. The gases leave at about the elevation of the centerline of the mud drum to meet a previously established breeching elevation. Flyash leaving the furnace is dropped in hoppers located at the bottoms of the last two passes. This material is discharged into the ash pit for disposal, no effort being made to re-inject this finely divided combustible into the furnaces.

A completely automatic combustion control system has been installed and consists of a metered air supply, forced draft control by means of fan louvers, which receive their impulse from header steam pressure and which is balanced against gas flow through the furnace. The furnace draft is controlled by automatically positioning the uptake dampers. The firing aisle and boiler board appear in Fig. 2, which reveals the structural details of the boiler fronts and shows the casing of the coal bucket elevator. The use of aluminum paint upon the equipment and cream colored paint on the walls enhances the appearance of the boiler room to a considerable degree.

Fig. 3. (Right) The new boiler control board. Each boiler has a boiler meter mounted on this panel, and a draft gage

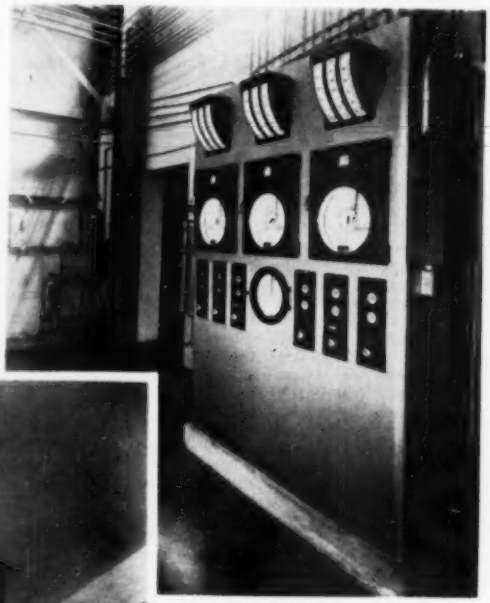


Fig. 4. (Below) A rear view of No. 2 boiler. This clearly shows the boiler feed piping, the Reeves variable speed drive for the stoker, uptake damper controls, plenum air chamber controls,

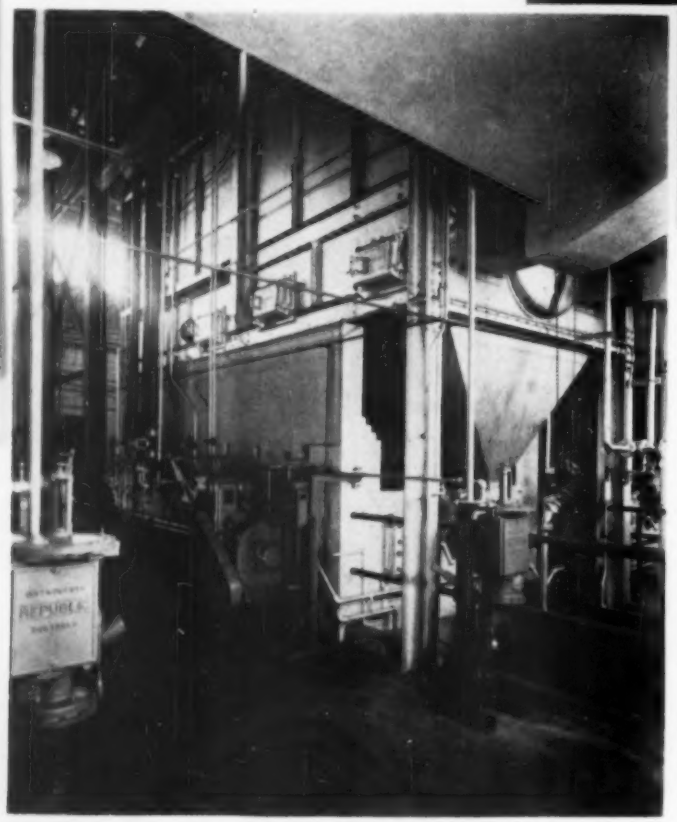


Fig. 3 is a closeup view of the boiler board. Each boiler has a boiler meter mounted upon this panel, which is equipped with steam flow, air flow and stack gas temperature recorder pens. A set of draft gages has been furnished to continuously indicate windbox, furnace pressure and uptake draft. Damper control levers indicate the settings of the plenum chamber dampers which zone control combustion air passing through the stoker to the furnace. The boiler board also contains a steam header pressure recorder and the controls for the automatic combustion control apparatus. The combustion control system and meters were furnished by the Republic Flow Meter Company. The right hand side of the boiler board reveals the alarm system which has been arranged to indicate low water level in the deaerator, high coal level in the bin, and the necessity for regeneration of one of the water softeners. This alarm system board has been located adjacent to the boiler board for convenience in the operation of the reset buttons and to furnish an indication of conditions in an area which is the most likely to be continuously occupied. Bindicators have been furnished to alert the operators to failure of fuel flow to the downtake chutes.

Furnace refuse falling from the stokers is accumulated in individual ash pits from which it is raked into a United Conveyor ash handling system. This equipment was selected because of its economy, ease of operation, and its contribution to the general cleanliness of the boiler

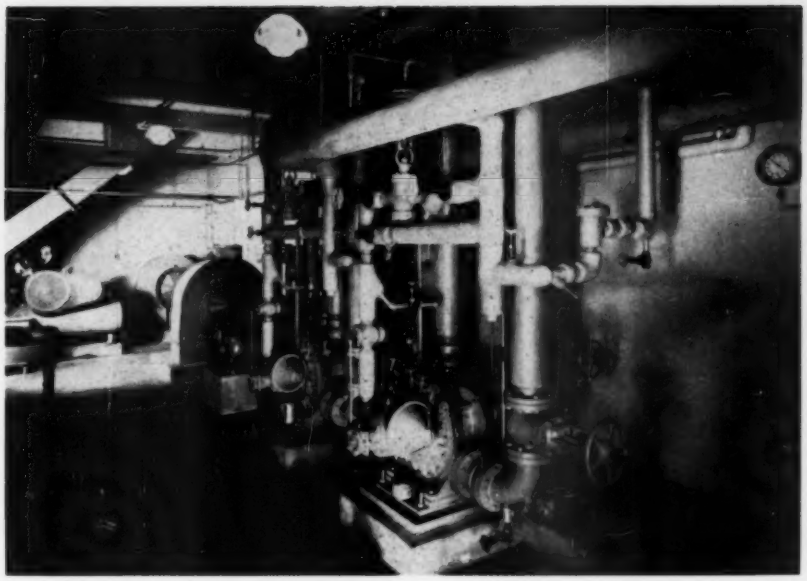


Fig. 5. Boiler feed pump, forced draft fan and compressor room. There are three boiler feed pumps, two driven by Coppus turbines and one by an electric motor

plant when in operation. A steam jet is employed to create a partial vacuum and furnace refuse is raked onto ash intakes and discharged to the external ash storage tank which appears prominently in Fig. 1. The ash tank is of vitrified glazed tile 9 ft inside diameter and 18 ft in height, and has a live discharge capacity of 20 tons. The furnace refuse is chuted from this ash storage to trucks by means of a dust suppression discharge chute which employs water sprays. It is possible to dispose of the furnace ash and fly ash with the creation of a minimum of dust nuisance in the area of the boiler plant.

Figure 4 is a view of the No. 2 boiler taken from the rear. It clearly shows the boiler feed piping, Reeves variable speed drive for the stokers, uptake damper control mechanism, plenum air chamber damper controls, and the ash pit in which the ash conveyor system operates.

The boiler feed pumps and forced draft fans were located in the area previously devoted to bunker storage of fuel for hand firing. Fig. 5 reveals the layout of this equipment and shows that there are three boiler feed pumps, two of which are driven by Coppus steam turbines and one by an electric motor. The boiler feed pumps are Ingersoll-Rand design and will furnish 60 gpm at 150 psi discharge pressure handling 125 F boiler feed water. Single element Northern Equipment Co., Copes regulators are installed upon each boiler to maintain the water level. The turbine driven pumps are also equipped with Fisher differential pressure pump governors for turbine control. Each boiler is equipped with an injector by means of which city water may be brought into a boiler in the event of power failure or loss of level in the deaerating heater. These injectors are each capable of delivering 1400 gal per hr of city water directly to the boiler drums. The background of Fig. 5 shows two of the three forced draft fans of Clarage design. Each fan has a capacity of 7500 cfm at 80 F against a 3 in. H_2O static pressure.

Boiler feedwater is taken from an Elliott deaerating heater with a capacity of 35,000 lb per hr at 215 F. The deaerator is mounted upon a storage tank of 6000 lb capacity providing approximately 15 min storage at the maximum anticipated load.

Condensate Return System

Practically all of the steam condensed in the various buildings is available for return to the boiler plant. A Nash vacuum return system was installed. It consists of two 91 gpm pumps suitable to operate with a suction pressure of 10 in. Hg vacuum and to discharge at 40 psig and a condenser receiver tank. This system has a simultaneous air removal capacity of 35 cu ft per minute at 10 in. Hg vacuum and at 70 F. The Nash return vacuum pump unit has been installed in a separate room beyond the forced draft fans. This compact installation is clearly shown in Fig. 6.

The plant is furnished with makeup water from the distribution system of the Borough of Kutztown and is passed through Zeolite softeners prior to mingling with the condensate in the deaerating heater. Makeup water varies in hardness from 130 to 204 ppm and Zeolite softeners appeared to be the simplest and most economical water treatment for makeup purposes available to this plant. Two (2) Hungerford & Terry, Inc. pressure type Zeolite softeners with a 30 gpm maximum capacity, 20 gpm normal, were installed, with sufficient capacity each to soften 13,800 gal of water of 204 ppm hardness as $CACO_3$ between regenerations.

Protection from possible cross connections to the school and to the borough distribution system has been effected by the installation of a Factory Mutual double check valve installation on the city water line entering the boiler plant. Every effort was made to make this installation conform to the requirements of the Commonwealth in regard to protection from cross connections.

Crystalization of the plans for the mechanical expansion of the plant demonstrated that the existing transformer bank consisting of three 25 kva transformer units would be inadequate. These were replaced by three 50 kva transformers to provide adequate power for boiler house requirements. Further, now underground cables had to be extended from the underground transformer vault to the boiler house.

As shown in Fig. 2 at the extreme right, a control center was installed to centralize power supply for motors, miscellaneous power, and lighting circuits. The control center was equipped with combination starts and air circuit breakers. Push-button controls for the auxiliary circuits were provided on the control center and at the several motors. All auxiliary drives are of 3 phase, 60 cycle, 220 v, a-c. The lighting and miscellaneous electrical outlet services were furnished at 110/220 v, 3 wire services. The alarm panel provides signals for all critical oper-

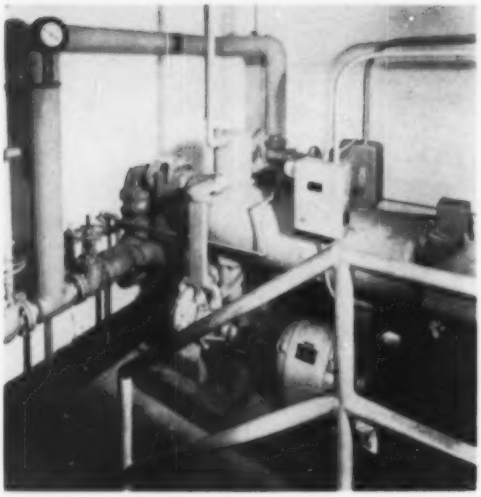


Fig. 6. Nash return vacuum pump unit

ational phases. A complete new lighting and grounding system was installed. Holophane fixtures mostly provide excellent illumination to all parts of the new plant. The newly installed grounding system grounds all motor frames and other electrical equipment.

The original building had a buff brick exterior and a cream colored brick interior. Every effort was made in making the extension to conform to this color scheme and to match the somewhat weathered colors of the original structure. Precast stone coping, sills and building trim were installed to enhance the eye appeal of the building. The fenestration consists of steel sash and steel doors with wired glass. The interior walls were finished in a light cream and gray colored paint and the boilers, piping and other equipment were painted aluminum. This combination renders the interior of the plant surprisingly light and colorful and places a premium upon maintaining the boiler room in a clean condition.

The roof of both the boiler plant proper and the service building consist of precast concrete slabs mounted upon steel purlins. This roof is of insulated construction and a membrane type of 20 year bonded roof with gravel protective coating was applied.

The service building which was erected to furnish an office and combination shower and locker room is a single story brick structure with a matching buff brick color which agrees with the color scheme of the remainder of the plant. The service building floors have been covered with asphalt tile for appearance and ease in maintaining clean conditions.

The exterior of the windows and doors has been painted green to match the painting upon the other buildings of the institution. Generally speaking, the architectural features of the boiler plant have been planned to match the architectural features of the other school buildings although the boiler plant is not prominently located and is invisible from the main entrance.

Regardless of the location, no effort was spared to make the boiler plant conform in architectural characteristics with the remainder of the buildings.

Originally the brick stack had been constructed of a buff brick outside to match the boiler plant building. The Bureau of Aeronautics, however, required that this stack upon its extension be painted in alternating International orange and white bands and that it be floodlighted from the ground. These steps were taken to minimize the hazard which the stack offers to aeronautical travel from a nearby airport.

The underground steam transmission and distribution system had undergone considerable deterioration and the Commonwealth felt justified in replacing the whole of this piping. A part of this replacement was made with Ric Wil presealed conduit and the remainder consisted of insulated steel pipe which was installed in an existing rectangular concrete conduit with removable concrete slab covers. This conduit contains the main 8 in. steam lead out of the plant and the 4 in. low pressure and 2½ in. high pressure pipe line returns.

Steam is passed through pressure reducing valves in the individual buildings in which it is used. All principal buildings at the school were equipped with automatic zone controls for temperature regulation as a part of this project. The automatic zone control system yields a better control of heating steam and assures a higher degree of comfort to the occupants of the buildings. Further, this type of control is most economical of steam since buildings are heated for maximum comfort only during such hours as they are occupied.

The author wishes to take this opportunity to express his appreciation for permission to publish the foregoing information, to Q. A. W. Rohrbach, A.M., Ph.D., President of the State Teachers College at Kutztown, Penna., and to the officers of the Pennsylvania Department of Property and Supplies.

MAN'S EFFORT to control and contain the floods of the Mississippi River are approaching completion, Brigadier General P. A. Feringa, President of the Mississippi River Commission, Vicksburg, Miss. told civil engineers at the 79th Annual Meeting of the American Society of Civil Engineers, in New York last month.

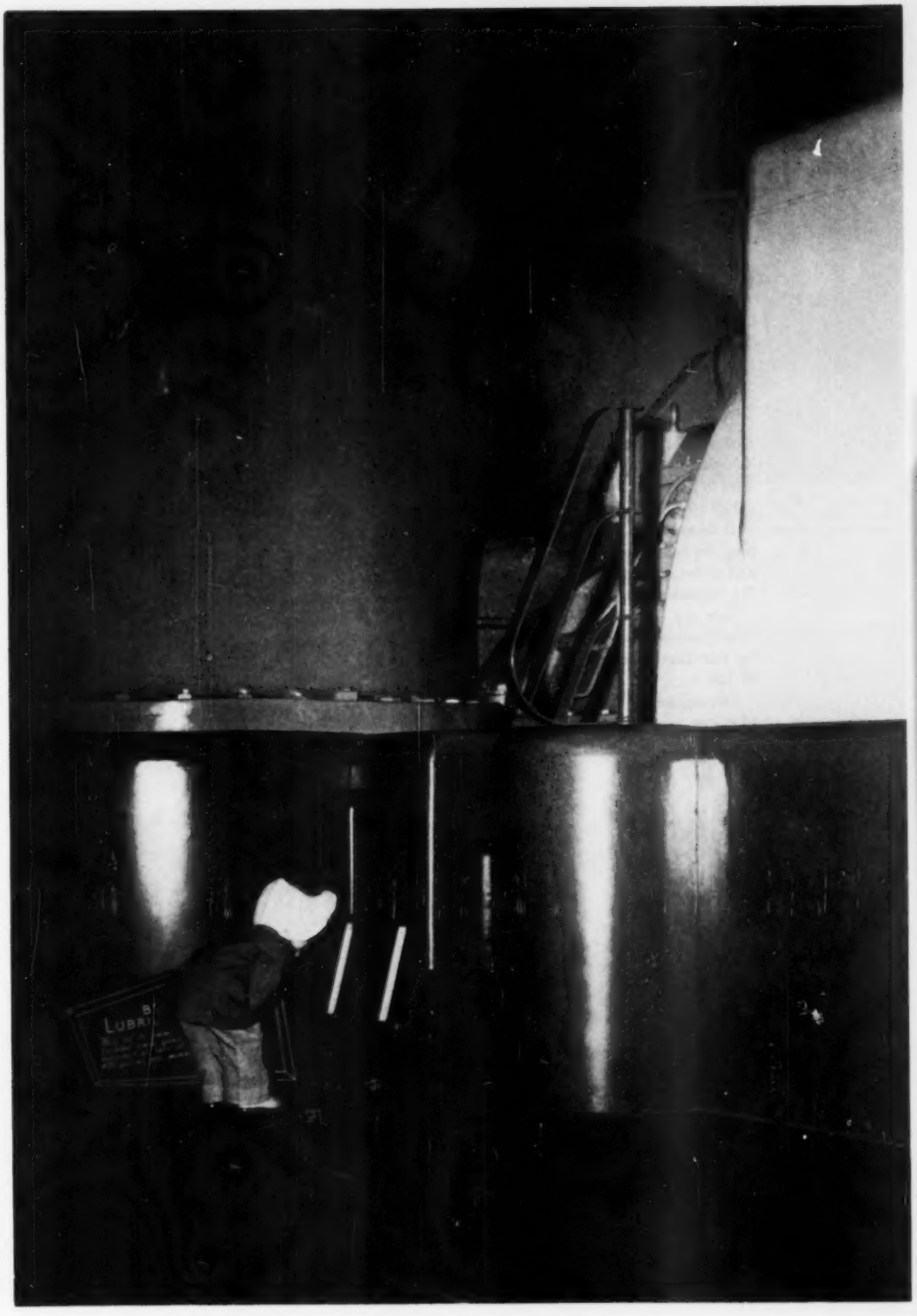
At the present time the river below Cairo, Illinois, is nearly contained between levees totaling 1,580 miles in length. By the end of the present fiscal year levee construction will be three-fourths complete.

When maximum floods on the Mississippi synchronize with maximum floods on its tributaries which together drain 1,240,000 square miles or 41 per cent of the area of the United States, 3,000,000 cfs of water will flow in the river below the mouth of the Arkansas.

Looking for Reddy Kilowatt ⟶ in Trenton Channel's New Unit No. 7

AT THE recent open house, October 18-31, 1949, at Trenton Channel Station of The Detroit Edison Co., where Unit No. 7 was put on display for the general public, 24,000 people from the Detroit area flocked in to see the great new generating unit. Eddie Smith, one of The Detroit Edison Company's photographers, who has been shooting pictures for DE for 12 years, brought along his 2½-year old daughter Kathie. At one point in the proceedings, Kathie had to check the turbine lubricating oil temperatures, thus giving Mr. Smith an opportunity to produce what we think is a masterpiece. (Perhaps she really was looking for Reddy Kilowatt.) The photo is by courtesy of *The Synchroscope*.

Unit No. 7 at Trenton Channel is a GE 100,000-kw, 1300-psi, 950-F tandem-compound turbine generator and was described in detail in PG, August 1948 issue. It is the first of two such units being installed as an extension to Trenton Channel, the second unit scheduled for completion in 1950.



ELECTRICAL WORK

Mobile Equipment Facilitates Power Line Pole Replacement

By JOHN M. GREEN

The Indianapolis Power & Light Company, Indianapolis, Indiana, has found that a ground wire mounted at the very top of the poles with the crossarms 6 ft below has materially decreased (by approximately 50 per cent) interruptions in power service. They are now installing this lightning protection on their entire major distribution system. The line is a 33 kv distribution line.

Their maintenance-installation crews are covering the major system, dropping the crossarms 6 ft on existing poles for the lightning protection system; and at the same time, replacing those poles which are unfit for further service. The replacement poles shown are 55 to 70 ft Black Diamond poles.

They are using an FWD Truck, Model CVA-BT with an auger, and a Bay City Cranemobile, Model T66. The Indianapolis Power & Light Company has for this Cranemobile, a series of booms which enable them to reach heights of 105 ft.

This equipment is capable of placing from 10 to 18 poles a day, depending, of course, upon soil conditions.

Fig. 1. This shows the FWD Truck with power driven auger for drilling the hole for the replacement pole

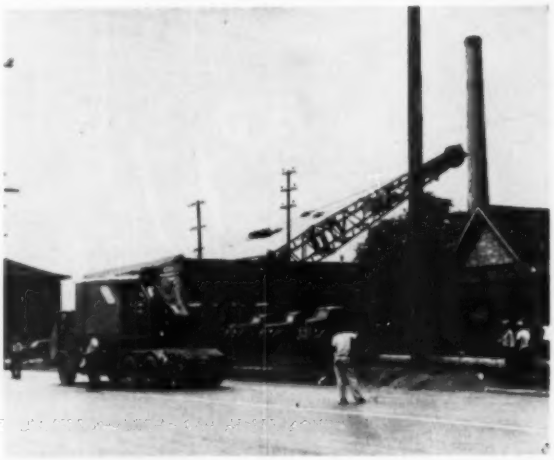


Fig. 2. The Bay City Cranemobile in position, ready to erect the new pole. The hole has been drilled adjacent to the old pole. The cable has been attached and the crane operator is ready to lift the pole

Fig. 3. Going up. The crane is starting to lift the pole while the crew is holding the lower end down

Fig. 4. Guiding the pole between the "hot" wires, ready to be dropped in place in the hole. This involves careful work on the part of both crane operator and crew

Fig. 5. (Above) Dropping the pole into place in the hole. This again, calls for perfect coordination between the crew and the crane operator

Fig. 6. (Left) Canting the pole. The pole is in place in the hole and the crew is setting it vertical by means of canting poles. The crane cable is kept taught

Fig. 7. (Above) This last view shows the pole in place (behind the old pole) ready to be tamped in. With this equipment, from 10 to 18 poles a day can be replaced

Relation of Plant Design To Reserve Capacity

Should a less expensive, inflexible system be used to increase the reserve capacity of a power plant, or is it more practical to install a costlier, more versatile addition? A study of the plant design and its effect on system reserve requirements is presented*; suggested method of evaluation of plans

By **M. J. STEINBERG,**
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New York, N. Y.

BECAUSE of conditions beyond the control of the electric power industry during and following the war years, the margin of capacity available for reserve has dropped to values generally considered to be below that standard that will assure continuity of service under reasonable forseeable conditions. With the addition of some 4,141,500 kw of net name-plate capacity during 1948, the year-end margin of reserve was only 5 per cent of the annual peak demand. The addition of some 6,700,000 kw during 1949 increased that margin to a value of but 8 per cent, and with planned capacity additions for succeeding years it is not expected that a satisfactory margin of reserve, which in most areas is now considered to be around 15 per cent, will be available until the end of 1951.

With costs for construction, operating labor, and materials at the highest levels in the history of the industry, coupled with difficulties in attracting equity capital to finance construction programs, planning and design engineers have been directing their main efforts and talents toward keeping investments in new plant capacity as low as possible.

A review of available literature descriptive of thermal plant design clearly indicates a trend toward the installation of single boiler—single turbogenerator for operation as a unit. Adoption of this arrangement is understandable in light of probable savings in operating personnel and reduction in investment by the elimination of valves, fittings and piping connections which are relatively expensive for service at high steam pressure and temperature. A further consideration is the fact that the reliability of such equipment approaches and possibly equals that of equipment designed to operate at low and intermediate values of pressure and temperature.

It is presumed that in many instances the choice of pressure-temperature combination, cycle design, and the size of boiler and turbogenerator units is made by an evaluation of differentials in thermal performance and operating costs for labor, material, and supplies. Too frequently the effect of plant design on system reserve requirements is overlooked or disregarded even though the latter may under conditions be more important than the differentials in operating costs.

The effect of such factors as the number and size of boiler and turbogenerator units, general arrangement, and design of equipment on the ability of the reserves of the system to maintain an objective degree of service reliability is capable of calculation by the application of the mathematical tool commonly referred to as the *probability method*.

The purposes of this article are to illustrate how general plant design, and in particular the interconnection of boiler and turbogenerator units affect system reserve requirements, and to suggest a method of evaluation of these factors.

Basic Design

For the purpose of this article it is assumed that a thermal plant with an ultimate capacity of 640 megawatts is to be added to an existing system. Six possible designs, illustrated schematically in Fig. 1, are analyzed and described in the following paragraphs.

Case 1. This installation consists of four turbogenerators each rated at 160 mw with four boilers of matching capacity arranged for unit operation by the elimination of a

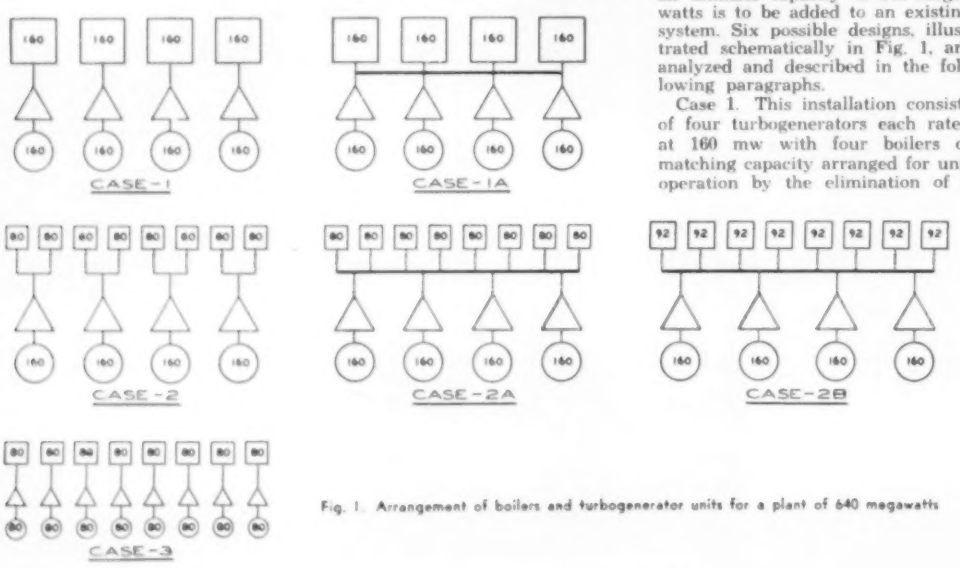

Fig. 1. Arrangement of boilers and turbogenerator units for a plant of 640 megawatts

* Presented at the Fall meeting of the American Institute of Electrical Engineers, Cincinnati, Ohio.

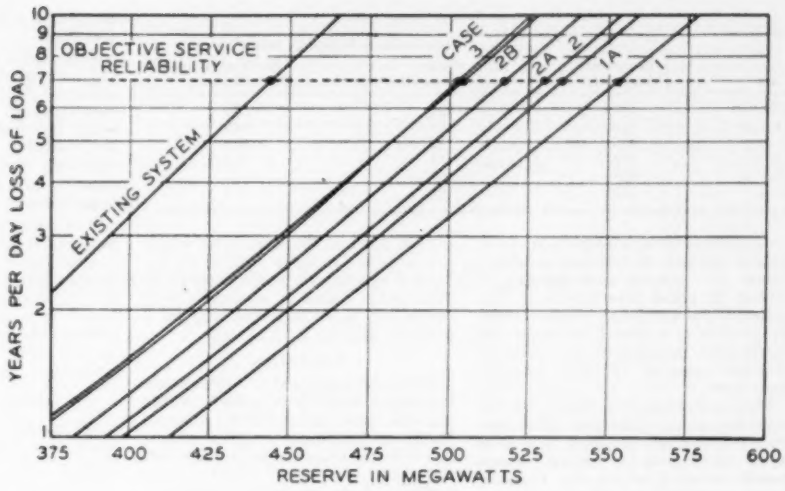

Fig. 2. Effect of plant design on system reserve capacity requirements (Calculated on a basis of 3 per cent forced outage rate for boiler and turbogenerator units.)

common steam header. This design is considered as the base case for reference on the assumption that it represents the current trend of design and that lowest investment per kilowatt of plant capacity is required for a selected pressure-temperature combination. Under this arrangement the outage of one boiler or turbogenerator unit represents a loss of 160 mw or one fourth of the plant capacity. The simultaneous outage of one turbogenerator and one noncompanion boiler represents a loss of 320 mw or one-half of the total plant capacity.

Case 1-A. This design is the same as that under *Case 1*, except that a common steam header has been added, the effect of which is to increase the flexibility of the plant since simultaneous outage of one turbogenerator unit and one noncompanion boiler results in a reduction of only 160 mw of plant capacity.

Case 2. The arrangement under this design provides for unit operation of one turbogenerator and two boilers of matching capacity. The outage of one boiler represents a reduction of 80 megawatts of plant capacity, while the simultaneous outage of one turbogenerator unit and one noncompanion boiler reduces the plant capacity by 240 megawatts.

Case 2-A. This design modifies that under *Case 2* by the addition of a common steam header. The addition of the steam header does not affect the capacity reduction due to the outage of a simple turbogenerator or boiler. It does, however, reduce the loss of capacity due to the simultaneous outage of one turbogenerator and one noncompanion boiler from a value of 240 megawatts to 160 megawatts.

Case 2-B. This design modifies that under *Case 2-A* by the introduction of boiler reserve equivalent to the capacity of one boiler, such that seven boilers will match the capacity of the four turbogenerator units, resulting in no loss of plant capacity due to the outage of any one boiler.

Case 3. This design utilizes eight turbogenerator units with eight matching boilers for unit operation as under *Case 1*. It has been added to show the effect of doubling the number of boilers and turbogenerator units.

From the standpoint of plant flexibility and availability for generation Table I summarizes the effect of outages discussed in the foregoing.

Evaluation Procedure

If it is to be assumed that the design under *Case 1* requires the lowest investment, then the evaluation of other designs should indicate what additional investment, if any, could be justified on the basis of any benefits to be derived which are not available with the design under *Case 1*. In the interest of brevity, this has been done by the evaluation of but three factors, which are considered to be predominant, to the exclusion of all others which are considered to be of minor importance. In general, the procedure follows that described in a paper previously presented before the Institute.

The results of the evaluation, shown in Table III, are based on the following points.

On-Peak Reserve Requirements

Systems serving metropolitan areas generally experience their annual peak demands during the winter months and more specifically in December. The installed capacity in excess of the annual peak demand is referred herein as "on-peak reserve." Capacity is added to an existing system primarily to meet the estimated growth in annual peak demand, and to increase the margin of capacity for reserve so that the objective degree of service reliability may be maintained with growth of peak demand. With respect to on-peak reserve requirements, the effect of plant design is illustrated by the curves of Figure 2 which were calculated on the basis of a 3 per cent forced outage rate for the boiler and turbogenerator units.

For an objective service reliability as measured by loss of load averaging one day in seven years, the system reserve requirements and the portion of new plant capacity allocated to system reserve are listed in Table II.

The difference between installed plant capacity and that allocated to reserve measures the growth in peak demand that can be accommodated by each design without reduction of the objective without reduction of the objective degree of service reliability. The design which permits

Table I. Megawatts Reduction of Plant Capacity Due to Outages

Case	One Boiler	One Turbogenerator	One Turbogenerator and One noncompanion Boiler
1	160	160	320
1A	160	160	160
2	80	160	240
2A	80	160	160
2B	0	160	160
3	80	80	160

Table II. System Reserve Requirements

Case	Requirements (Megawatts)	Requirements Added by New Plant: Power (Megawatts)	Requirements Added by New Plant: Per Cent of Plant Capacity
1	553	108	16.9
1A	536	91	14.2
2	530	85	11.8
2A	517	72	11.3
2B	504	59	9.2
3	503	58	9.1

accommodation of a larger peak load growth because of reduced requirements for reserve also permits a saving in plant investment to the extent of such reduced requirements for reserve and should be evaluated at the unit investment per kilowatt of plant capacity required for the base case.

This is indicated in Table III for investments at $150 and $200 per kilowatt of plant capacity, and it is to be noted that the added investments justified above for *Case 1*, when expressed in per cent of investment required for *Case 1*, do not vary materially.

Availability for Generation

For the same degree of service reliability and same on-peak demand, *Case 1* would require plant capacity in excess of 640 mw by the amounts indicated as item 2 of Table III. The larger installed capacity requirements for *Case 1* will, however, permit proportionately increased generation. This is indicated as a credit to *Case 1* by item 6 of the same table. Availability for generation was based on scheduled overhaul requirements of two months outage every four years for each turbogenerator, and one month annually for each boiler in the system.

Off-Peak Reserve Requirements

The term "off-peak" has reference to the period approximately from June 15 to September 15, during which it is common practice to schedule overhaul of equipment commensurate with reduced levels of peak demand in this period. Many systems, however, are experiencing rapid growth of summer peak demands making it difficult to accommodate requirements for overhaul. Continuation of this trend will soon make necessary the addition of capacity for overhaul purposes.

In this connection the design under *Case 2-B* offers advantages not available under the other design. For example, in *Case 1*, outages for overhaul will result in a loss of 160 megawatts of plant capacity for five months in each year. For *Case 2-B*, this outage is reduced to two months. It follows, therefore, that there is a differential gain in availability of 160 megawatts of plant capacity for three months during which additional outages for overhaul elsewhere on the system can be accommodated.

A capacity of 160 megawatts which is available for three months in the year is considered equivalent to 40 megawatts which is available year round and is so indicated as item 3 of Table III.

Conclusions

Although adoption of the single boiler-single turbogenerator design for unit operation will tend towards the least investment for plant capacity, it does not necessarily represent the most economical choice when considered in relation to basic requirements for system reserve, overhaul requirements, and availability of plant capacity for base-load operation.

The effect of connecting boilers and turbogenerator units through a common steam header reduces the requirements for system reserve, while the installation of boiler reserve with a common steam header increases the availability of plant capacity in addition to reducing the requirements for system reserve.

It is recognized that acceptance of the results presented in this article is conditioned upon acceptance of the method of evaluation employed and the assumptions upon which it is based. It is believed, however, that comparable results will be obtained by any other acceptable method of evaluation.

Influence of Reheat Units

All possible designs have not been considered among which might be included the currently popular reheat-regenerative cycle. It is more than of passing interest to note that approximately 2,500,000 kw of capac-

Table III. Evaluation of Designs for a 640-Megawatt Thermal Plant

Case	1	1A	2	2A	2B	3
1. Incremental on-peak reserve capacity requirements at three per cent forced outage rate (in megawatts)	108	91	85	72	59	58
2. Reduction in reserve capacity requirements (Case 1 as base) (in megawatts)		17	23	36	49	50
3. Capacity equivalent of increased availability of 160 megawatts for three months per year (in megawatts)					40	
4. Total reduction in capacity requirements (Case 1 as base) (in megawatts)		17	23	36	89	50
5. Value of reduction in capacity requirements						
(a). For plant investment at $150 per kilowatt (in thousands of dollars)		2,550	3,450	5,400	13,350	7,500
(b). For plant investment at $200 per kilowatt (in thousands of dollars)		3,400	4,600	7,200	17,800	10,000
6. Credits to Case 1 for increased generation due to larger installed capacity requirements						
(a). Increase in generation at 75 per cent output factor $\times 10^6$ kilowatt-hours		13	135	124	261	294
(b). Annual fuel savings due to increased generation (in thousands of dollars) Differential heat rate at 5,000 Btu per kilowatt-hour Fuel priced at $0.30 per million Btu		19	203	186	392	441
(c). Credit to Case 1 at 6.25 times annual fuel saving (in thousands of dollars)		118	1,266	1,164	2,447	2,756
7. Justified added investment above Case 1 for plant investment at $150 per kilowatt						
(a). Total (in thousands of dollars)		2,432	2,184	4,236	10,903	4,744
(b). Per kilowatt of plant capacity		$3.80	$3.40	$6.68	$17.00	$7.40
(c). Per cent of investment for Case 1		2.5	2.3	4.4	11.3	4.9
8. Justified added investment above Case 1 for plant investment at $200 per kilowatt						
(a). Total (in thousands of dollars)		3,282	3,334	6,036	15,353	7,244
(b). Per kilowatt of plant capacity		$5.13	$5.20	$9.40	$24.00	$11.30
(c). Per cent of investment for Case 1		2.6	2.6	4.7	12.0	5.7

ity is under construction or being contemplated which employs this cycle. Because it is not practical to design such installations with common steam headers, they have the objections noted in the article for the design under *Case 1*. Whether the five per cent gain in thermal efficiency which is attributed to this cycle is sufficient to overcome the advantages of a regenerative cycle with a common steam header and boiler reserve, as indicated by *Case 2-B*, is a matter worthy of more serious consideration in the design of a plant.

A five per cent gain in thermal efficiency is equivalent to a reduction in heat rate of approximately 500 Btu per kilowatt-hour. The additional investment justified by the fuel savings above *Case 1* is approximately $6.20 per kilowatt of plant capacity.

When Doctors Disagree on Densities of Gases

By J. R. DARNELL

RECENTLY the author had occasion to check certain combustion calculations for gaseous hydrocarbons containing methane and ethane. This also involved the need for ascertaining correct values for the weight per cubic foot of each of these gases. Observations in various handbooks indicated some discrepancies in these values and this led to a general scrutiny of densities for all of the various gases shown in the accompanying table. Since some handbooks give values at 32 F and others at 60 or 68 F, the author has corrected all values to 32 F.

Since the density of any gas, compared with another at the same temperature and pressure, is supposed to vary directly as their respective molecular weights, then if one knew which density were correct for any given gas, correct densities for the other gases could be computed. For example, if we were to assume that the correct density of oxygen at 32 F is 0.08921 lb per cu ft, then, since the ratio of the molecular weight of methane to that of oxygen is 16.03 ÷ 32.00 or 0.501 to 1.0, then the correct density of methane should be 0.08921 × 0.501 or 0.04469 lb per cu ft. Some of the values in the accompanying tables are as high as 0.0475 and one is given as 0.045 lb per cu ft.

Using this same method of comparison, the ratio of molecular weights of carbon dioxide and oxygen is 44.01 ÷ 32.00 or 1.3753 to 1.0. Accordingly the correct density for carbon dioxide should be 0.08921 × 1.3753 or 0.122691 lb per cu ft. Nevertheless, some handbooks give values as high as 0.12341 for carbon dioxide.

In like manner, since the molecular weight of sulfur dioxide is approximately double that of oxygen, their densities should be in the same ratio. However, if we multiply the oxygen density value by the ratio of molecular weights we get 0.08921 × 2.002 or 0.1786 lb per cu ft as the density for sulfur dioxide. Compare this figure with the value of 0.1827 listed by three of the authorities in the accompanying tabulation.

We realize, of course, that there may be some question as to whether certain gases are "perfect" and conform exactly to the laws for perfect gases. The author suggests that professors in engineering schools with ample facilities arrange to have some of their graduate students, working for doctor's degrees, conduct sufficient tests to arrive at accurate values of densities for those gases ordinarily encountered in combustion calculations.

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Table showing variations in densities of gases in lb per cu ft at 32 F and 30 in Hg, as published by different authorities as noted in list of references

	1 Cochrane	2 Helios	3 Pratt and Steam	4 Marks	5 Kent	6 White	7 Haslam	8 Marks	9 Chemical Rubber	10 Mol. Wt.
Air	0.08071	0.08071	0.08071	0.0807	0.080728	0.0809		0.08078	0.08071	28.94
Oxygen	0.08922	0.08922	0.08921	0.0892	0.08921	0.08942	0.08916	0.08331	0.08921	32.00
Nitrogen	0.07829	0.07812	0.07807	0.0783	0.07831	0.078535	0.07806	0.078065	0.07846	28.02
Hydrogen	0.005621		0.00562		0.00559	0.00560	0.00561	0.00562	0.005611	2.015
Carbon Dioxide	0.12269	0.12341	0.12341	0.1227	0.12267	0.1230	0.12259	0.12256	0.12341	44.01
Carbon Monoxide	0.07807		0.07806		0.07807	0.07842	0.07802	0.07801	0.07806	28.01
Methane	0.04479	0.04470	0.04500			0.04475	0.04467	0.04468	0.04475	16.03
Ethane			0.0847			0.08393	0.08371		0.08469	30.05
Acetylene	0.07254		0.07425	0.0725	0.07251	0.07272	0.07241	0.07248	0.07323	26.03
Ethylene			0.07808	0.0780	0.07809	0.07842	0.07811	0.07813	0.07868	28.03
Sulfur Dioxide	0.17862	0.18271	0.18272	0.1786	0.1787	0.17916			0.1827	64.07
Water Vapor					0.05020	0.05032	0.05020			18.02

Basic Power Plant FIGURING

A Review for Old-Timers

A Must for Young-Timers

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How to Calculate Steam and Water Flow in Surface Condensers for Steam Turbines

HERE ARE some problems in steam and water flow in surface condensers. These flows must be determined before the condenser itself can be designed for a specific unit.

Note that both summer and winter water conditions must be calculated. Design or selection of the condenser for a specific turbine unit must take into account not only the steam and water flow conditions but also the diameter, length and number of condenser tubes, also a "cleanliness factor." To obtain rapidly an accurate estimate of the proportions of surface condensers, taking the above factors into account, see article Simple Condenser Proportioning, by W. H. Armitage *Power Plant Engineering*, November 1947. That article shows typical charts by which the size of a condenser for a given performance may be determined.

Problem 1: A 10,000 kw turbine generator operating at 400 psia and 700 F total temperature has a steam rate of 12 lb per kwhr when condensing. The vacuum in the condenser is 28 in. Hg referred to 30-in. barometer. The exhaust steam entering the condenser contains 10 per cent moisture. In winter, the condenser cooling water enters at 50 F and leaves at 90 F. In summer, the condenser cooling water enters at 80 F and leaves at 95 F. The circulating pump operates with an 8 ft suction lift, a 32 ft discharge head, and at an efficiency of 60 per cent.

Find:

a. Pounds of steam per minute to be condensed.
b. Total Btu per minute the condenser must extract.
c. Pounds of cooling water required in winter and summer.
d. Horsepower required to operate the pump in winter and summer.

The terminal temperature difference of the condensate and the cooling water is a small item and can be neglected; hence the Btu to be condensed are those necessary for the evaporation less the moisture.

Exhaust steam: $30 - 28 = 2$ in. Hg abs, $t = 101.14$, $h_{fg} = 1036.6$
$(1.00 - 0.10)\ 1036.6 = 933$ Btu per lb to be extracted.

a. Total flow is $10{,}000 \times 12 = 120{,}000$ lb per hr $= 2{,}000$ lb per min to condenser.
b. $2{,}000 \times 933 = 1{,}866{,}000$ Btu per min to be extracted.
c. SUMMER: $1{,}866{,}000 \div (95 - 80) = 124{,}400$ lb cooling water req'd per min.
$124{,}400 \div 8.33 = 14{,}934$ gpm cooling water req'd.
d. $Hp = \dfrac{124{,}400\ (32 + 8)}{33{,}000 \times 0.6} = 251.3$ (ANSWER)

WINTER: $1{,}866{,}000 \div (90 - 50) = 46{,}650$ lb cooling water required per min.
$46{,}650 \div 8.33 = 5{,}600$ gpm cooling water required.

$$Hp = \frac{46{,}650 \times 40}{33{,}000 \times 0.6} = 94.24 \text{ (ANSWER)}$$

NOTE: With modern surface condensers and an almost air-tight system, the condensate temperature will be from zero to 5 deg lower than the exhaust steam at condenser pressure, the temperature of the cooling water leaving will range 8 to 15 deg below that corresponding to the vacuum. At the usual absolute condenser pressure from 0.75 to 1.75 in. mercury, practical calculations consider a heat absorption of 950 Btu per lb. This allows for an average of 10 per cent moisture in the exhaust steam.

NOTE: Values for lift and discharge head on circulating pumps must include pipe friction losses, known or assumed, if accurate calculations are to be made for pump horsepower. Friction losses in circulating water piping are shown by tables and charts in Marks' and Kent's Handbooks. Losses in condenser water boxes and tubes are shown in chart, page 104, ***Power Plant Engineering***, November 1947.

Problem 2: A 20,000 kw condensing bleeder turbine operating at 400 psia and 700 F has a steam rate of 11.5 lbs per kw hr. But 20 per cent of the steam is bled into the heating system or used as process steam. The quality of exhaust steam is 92 per cent. Average vacuum in condenser during summer is 28 in. ref. to 29½ in. barometer. Average vacuum in condenser during winter is 29 in. ref. to 30 in. barometer.

Cooling water inlet temperature is 70 F in summer and 45 F in winter. The terminal difference between condensate and the cooling water leaving is 4 F. The circulating pump operates under the following condition: The suction lift in summer is 15 ft and in winter 5 ft. The discharge head in summer is 40 ft and in winter 32 ft. The average efficiency is 60 per cent.

Calculate: Quantity of cooling water for summer and winter operation, and the horsepower required to drive the circulating pump.

Total Flow: $20{,}000 \times 11.5 = 230{,}000$ lb per hr to turbine.
Bled Steam: $= 230{,}000 \times 0.20 = 46{,}000$ lb per hr to heating system.
Difference is $184{,}000$ lb per hr to condenser.

SUMMER OPERATION: $29.5 - 28 = 1.5$ in. Hg abs; $t = 91.7$ $h_{fg} = 1042$ Btu.
$H = 1042 \times 0.92 = 959$ Btu per lb in exhaust steam.
184,000 lb per hr is 3,067 lb per min.
$3{,}067 \times 959 = 2{,}941{,}253$ Btu to be extracted in condenser.
Temp of cooling water leaving $= 91.7 - 4 = 87.7$ F.
Temp rise of cooling water $= 87.7 - 70 = 17.7$ F or 17.7 Btu.
$2{,}941{,}253 \div 17.7 = 166{,}172$ lb or 19,950 gpm cooling water.

$$Hp = \frac{166{,}172 \times (40 + 15)}{33{,}000 \times 0.6} = 461.6$$

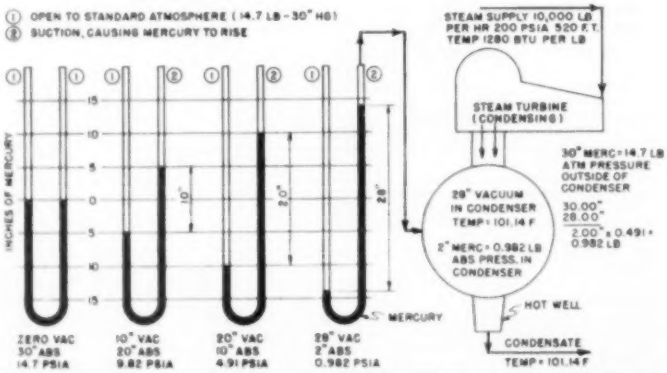

Fig. 1. Use of mercury column for measurement of condenser vacuum. See Problem 3

WINTER OPERATION: 30 — 29 = 1 in. Hg abs; t = 79.0; h_{fg} = 1049.2 Btu.
H = 1049.2 × 0.92 = 965.3 Btu per lb in exhaust steam.
3067 × 965.3 = 2,960,575 Btu to be extracted in condenser.
Temp of cooling water leaving = 79.0 — 4 = 75.0 F.
Temp rise of cooling water = 75 — 45 = 30 F or 30 Btu.
2,960,575 ÷ 30 = 98,686 lb or 11,847 gpm cooling water.

$$Hp = \frac{98{,}686 \times (32 + 5)}{33{,}000 \times 0.6} = 184.4$$

Problem 3: A 500 kw turbine generator uses 10,000 lb of steam per hour. Vacuum in condenser is 28 in. referred to 30 in. barometer. The cooling water leaves the condenser at 10 deg below the steam temperature in condenser. The cooling water picks up 15 deg during the circulation.

Find:

a. Pounds of steam to be condensed per minute.
b. Steam temperature in condenser.
c. Btu per pound of steam to be extracted.
d. Cooling water required in gallons per minute.

Solution:

a. 10,000 ÷ 60 = 167 lb of steam per minute to be condensed.
b. 30 — 28 = 2 in. Hg abs; (Steam Table 2) t = 101.14 F use 101 F.
c. 1105.7 — (101 — 32) = 1,036.7 Btu per lb to be extracted.
Temperature of cooling water leaving: 101 — 10 = 91 F.
Temperature of cooling water entering: 91 — 15 = 76 F.
Btu absorbed by cooling water 15
1,036.7 ÷ 15 = 69.1 lb of water to condense 1 lb of steam.
d. $\frac{167 \times 69.1}{8.33}$ = 1,385 gpm cooling water required.

Problem 4: A 300 kw turbine generator has a steam rate of 30 lb per kw hr. The vacuum in the condenser is 27 in. referred to 29.5 in. barometer. The condenser circulating water leaves at 8 deg below the steam temperature and has picked up 20 deg.

Find:

a. Pounds of steam to be condensed per minute.
b. Steam temperature in condenser.
c. Temperature of circulating water entering condenser.
d. Btu per pound of steam to be extracted.
e. Circulating water required in gallons per minute.

Solution:

a. 300 × 30 = 9,000 lb steam per hour or 150 lb per min.
b. 29.5 — 27 = 2.5 in. Hg abs; (Steam Table 2) t = 108.7
c. Temp of cooling water leaving: 108.7 — 8 = 100.7 F.
Temp of cooling water entering: 100.7 — 20 = 80.7 F.
The condensate temp is assumed to be the same as the steam.
d. Heat in exhaust steam is 1032.3 Btu per lb to be extracted
e. $\frac{150 \times 1032.3}{8.33 \times 20}$ = 929.44 gpm cooling water required.

Problem 5: A 5,000 kw turbine generator operating at 300 psia and 600 F has a steam rate of 12 lb per kw hr. At the 5th stage, 10 per cent of the steam is extracted for processing. Steam entering the condenser contains 10 per cent moisture. Vacuum in condenser is 28.05 in. Hg referred to a 29.66 in. barometer. The circulating water enters at 64 F and leaves the condenser at a 8 deg below steam temperature. The circulating pump operates under the following conditons: The suction gage is attached 2.5 ft below center line of pump and shows a vacuum of 9.24 in. Hg. The discharge gage reads 35 ft and is located 2 ft above center line of pump. The pump efficiency is 68 per cent.

Find:

a. Pounds of steam to be condensed per minute.
b. Steam temperature in condenser.
c. Temperature of circulating water leaving condenser.
d. Btu per pound of steam to be extracted.
e. Total Btu per minute the condenser must extract.
f. Total pounds of cooling water required per minute.
g. Required capacity of circulating pump in gpm.
h. Water hp of pump (theoretical hp).
i. Actual shaft hp or brake hp required.

Solution:

Steam consumption per hour is 5,000 × 12 or 60,000 lb.
Steam extracted per hour is 10 per cent or 6,000 lb.
Steam entering condenser is difference or 54,000 lb per hr.
a. Steam to be condensed per minute is 900 lb.
b. 29.66 — 28.05 = 1.61 in. abs; t = 94 F (Steam Table 1).
c. 94 — 8 = 86 F (temp. of circ. water leaving)
d. 0.9 × 1040.7 = 936.6 Btu per lb to be extracted.
e. 936.6 × 900 = 842,940 Btu total to be extracted per minute.
f. 842,940 ÷ 22 = 38,315 lb of cooling water per minute.
g. 38,315 ÷ 8.33 = 4,600 gpm.
Suction lift is 10.5 plus 2.5 or 13 ft.
Discharge head is 35 plus 2.0 or 37 ft.
Total head on pump is: 50 ft.
h. Water hp is $\frac{38{,}315 \times 50}{33{,}000}$ = 58.05 (theoretical)
i. Actual hp is 58.05 ÷ 0.68 = 85.4 (brake hp).

ENGINEERS BOUNCE RADIO WAVES AROUND MOUNTAIN TO CONTROL POWER PLANT

Microwave communication system recently installed between a sub-station and generating plant of the Pennsylvania Electric Co. at Johnstown has shown the reflection principle to be both efficient and economical. The sub-station and generating plant are 12 miles apart and the expense of installing and maintaining multiple telephone lines for control purposes would have been considerable.

Microwaves travel only in a straight line and at the Johnstown installation there is a large hill between the sub-station and the generating plant. Since the waves would not go over this hill or through it, the beam was reflected around it.

In operation the microwaves are beamed at a large aluminum reflector sheet placed some two miles from the sub-station. This sheet, 20 ft square, is mounted on a 50-ft tower and is in the "line of sight" of both the sub-station and the generating plant. Microwaves striking this mirror-like reflector are deflected around the side of the mountain to the receiving apparatus.

This "bent" radio beam makes it possible for the load dispatcher at the sub-station to have direct control of the generating plant.

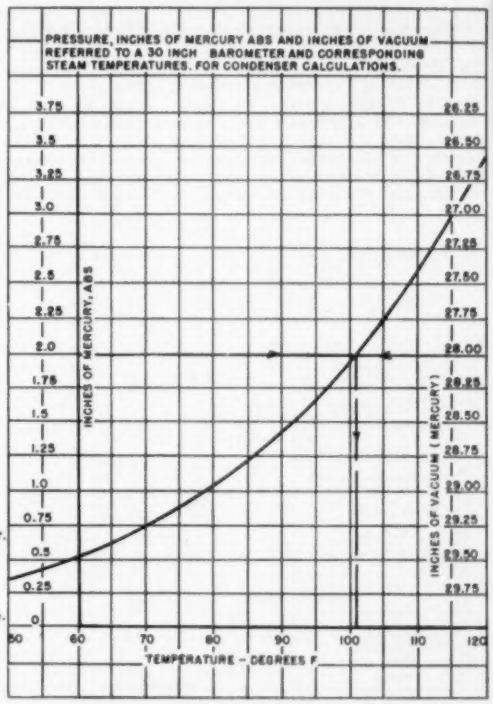

Fig. 2. Relations between pressure in inches of mercury, inches of vacuum referred to 30-in barometer and corresponding steam temperatures, for use in condenser calculations

Fig. 1. Typical Marion Power Shovel in operation. (Automobile, lower left, shows comparative size of shovel)

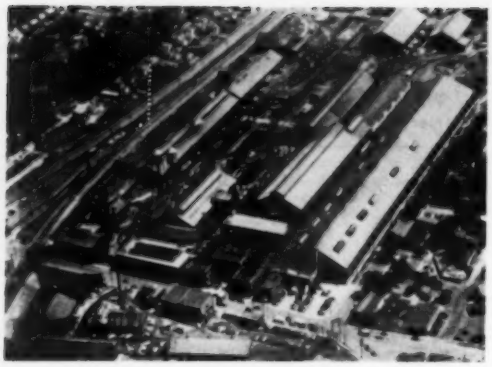

Fig. 2. Marion Shovels are built in this 25-acre plant, now served by modernized power house described below

How Marion Power Shovel Co. Modernized Its Steam Plant

By G. R. KILBOURN Plant Engineer Marion Power Shovel Co.

MANUFACTURE of Marion Power Shovels, Fig. 1, at the large plant of Marion Power Shovel Co., Marion, Ohio, shown in Fig. 2, involves all the problems of fabricating heavy special machinery. Such manufacturing operations require the most reliable, economical supply of steam and power and this article shows how the steam generating facilities of this plant have recently been modernized to secure that reliability and economy.

Although the power shovels manufactured at this plant are built to certain basic designs and may contain standardized components, they may also differ in important details to fit a particular application. Hence they cannot be manufactured by assembly-line or mass-production methods. Skilled mechanics must heat treat forgings; shape them on steam hammers; bend and weld and bolt castings, shapes, forgings, plates; install engines; form caterpillar treads; and a host of other operations.

Load Conditions

Large amounts of power are required for these operations; compressed air must be supplied for air tools, hoists and the like; direct-current power is required for certain machine tools, cranes and hoists and other special equipment; large amounts of steam are required by steam hammers.

Up to 1948 these services were

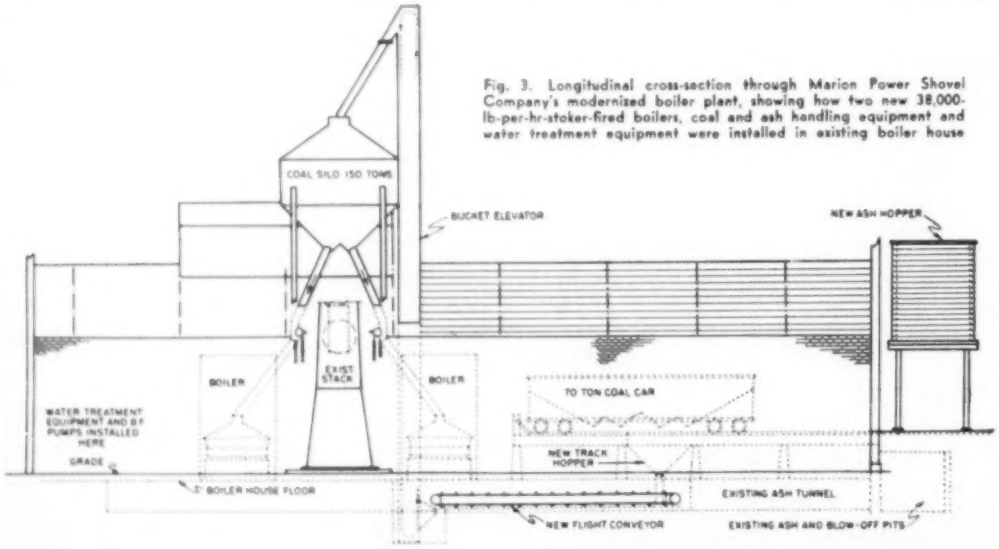

Fig. 3. Longitudinal cross-section through Marion Power Shovel Company's modernized boiler plant, showing how two new 38,000-lb-per-hr-stoker-fired boilers, coal and ash handling equipment and water treatment equipment were installed in existing boiler house

provided by coal-fired firetube boilers installed many years ago. As soon as the war was over, it became possible to consider modernizing this plant to lower power and steam costs. Careful analysis had already led to removal of the old steam engine driven generators and purchase of all required electricity from the local utility company.

Accordingly, Frederick L. Smith, consulting engineer, of New York, was retained to make studies and to design a power plant that would meet all power needs efficiently and reliably. This design was carried out, and the construction supervised by, the consultant in close co-operation with the author and his assistant, E. A. Mulvaine.

As a result in 1948, new steam generating equipment was installed in the existing boiler house, all the old boiler equipment was removed and the boiler plant now appears as shown in the illustrations. Detailed data on the new equipment are given in the list of equipment.

The existing boiler house was utilized to house the new equipment, the removal of a number of old boilers leaving sufficient space for two new steam generating units, all the water treatment and pumping equipment and for extending the railroad track inside the building, as shown in Fig. 3, to permit a car of coal to be unloaded inside.

Two New Boilers

The two new boilers are of the Wickes two-drum bent-tube type, with water-cooled furnaces, fired by spreader stokers as shown in Figs. 4 and 5. Each boiler is designed for an output of 35,000 to 38,000 lb of steam per hr maximum and is at

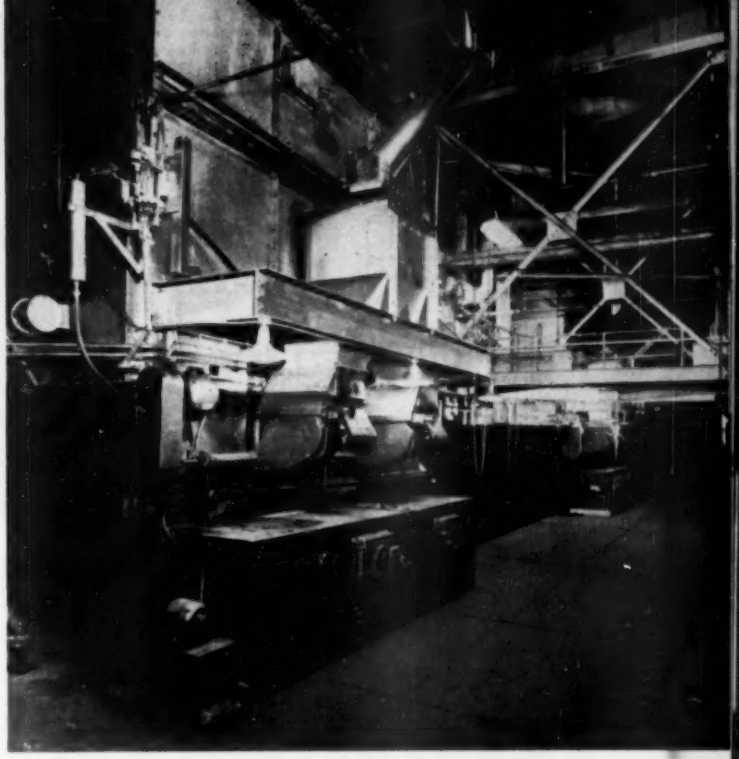

Fig. 4. General view of two new 38,000 lb-per-hr, spreader-stoker-fired boilers at Marion Power Shovel Co.

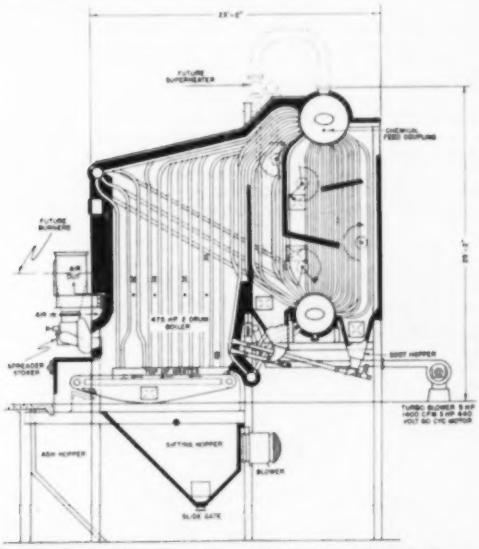

Fig. 5. Cross-section through one of two 38,000 lb-per-hr boilers at Marion, showing water wall furnace, stoker, fly-ash re-injection system

List of Equipment, Marion Power Shovel Co., Marion, Ohio

BOILER EQUIPMENT

Boilers:—Two 2-drum bent-tube, designed for 450 psig, 35,000/38,000 lb steam per hr, each, with a total heating surface in each boiler and water walls of 5340 sq ft. The Wickes Boiler Co.
Stokers:—Two AE Perfect Spread Stokers, traveling grate. American Engineering Co.
Induced Draft Fans: Two 33,600-cfm each, 6.5 in. at 550 F, driven by turbine and motor. Buffalo Forge Co.
Forced Draft Blowers:—Two BFS Wing motorized blowers complete, 16,700 cfm each at 4 in. L. J. Wing Manufacturing Co.
Fly Ash and Dust Collector:—Multiclone type, 9 VG, size 40-4, 28,000 cfm each. Western Precipitation Corp.

BOILER ACCESSORIES

Feedwater Regulators:—Copes—Northern Equipment Co.
Soot Blowers:—Diamond Power Specialty Corp.
Blow-off Valves:—Yarnall Waring Co.
Water Columns:—Reliance Gauge Column Co.

COAL AND ASH HANDLING

Coal Handling:—Track hopper; flight feeder; bucket elevator; coal bunker and chute system and coalimit device. Fairfield Engineering Co.
Ash Handling:—Intermittent full vacuum, ash conveyor system and ash storage bin. The National Conveyor Co., Inc.

FEEDWATER HEATER, WATER SOFTENER EQUIPMENT AND PUMPS

Feedwater Heater:—Deaerating type, maximum capacity 77,000 lb per hr. Worthington Pump and Machinery Corp.
Hot Process Water Softener:—Non-deaerating type, capacity 30,000-lb per hr. Worthington Pump and Machinery Corp.
Boiler Feed Pump:—One 2 in. Type RR, 2-stage, centrifugal 160-gpm, at 195 psi, 3500-rpm, Buffalo Pumps, Inc., driven by Coppus steam turbine.
Booster Pump:—One 2-in., single-suction, centrifugal 160-gpm, 3500-rpm, Buffalo Pumps, Inc., driven by Coppus steam turbine.
Condensate Return System: Aurora Pump Co.
Transfer Pump:—One 2-in. single-suction, 70-gpm, 3500-rpm, Buffalo Pumps, Inc., driven by Coppus steam turbine.

CONTROL AND INSTRUMENTS

Automatic Combustion Control Equipment:—Hagan Corp.
Steam-Flow-Air-Flow Meters:—Hagan Corp.
Water Level Indicators:—Reliance Eye-Hye remote water level indicator. Paul B. Huyette Co.

GENERAL

Duct Work:—Tippett and Wood.
Condensate Tank:—National Tank Equipment Co.
Gages:—Manning, Maxwell and Moore.
Piping:—Charles M. Brown and Co.
Boiler Setting:—George Allen and Son.
Water Treatment Consultants:—W. H. & L. D. Betz.
Consulting Engineer:—Frederick L. Smith.

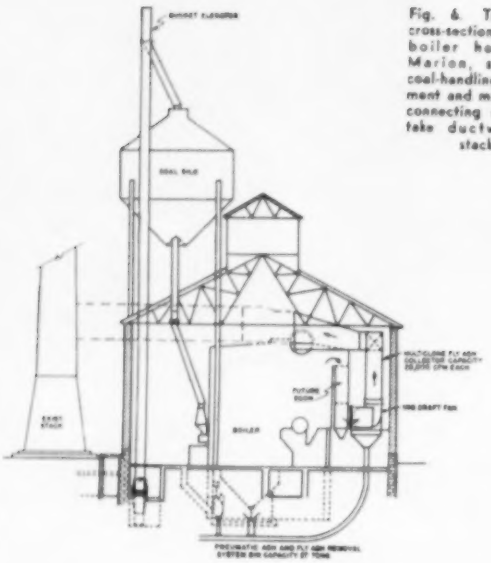

Fig. 6. Transverse cross-section through boiler house at Marion, showing coal-handling equipment and method of connecting new uptake ductwork to stack

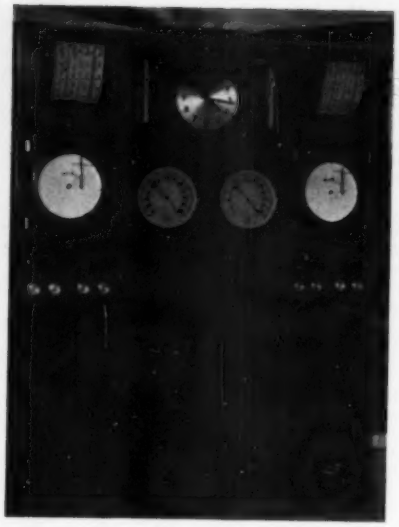

Fig. 7. Boiler control panel

present operated at 150 psi working pressure, although built for 450 psi so that it can supply steam to turbine generator units if they are ever installed. For the same reason, the boiler design provides for future installation of a superheater. At present, however, the steam hammer load of 150-psi steam consumes practically the entire output of one boiler and in the winter when building heating is required, both boilers are operated at moderate outputs. Steam hammers, of course, produce sharp load swings on these boilers, as shown by the typical steam-flow-air flow charts of Fig. 8, but the units handle them satisfactorily and without too severe fluctuations in water level and steam pressure.

Provision is also made in the design for future addition of economizers, if desirable or necessary.

Spreader Stoker Details

Each boiler is fired by a Perfect Spread stoker of the traveling grate or continuous ash discharge type. Coal is to be the basic fuel for the plant but the boiler fronts are arranged so that oil or gas burners can be installed if it becomes more economical to burn those fuels.

The stokers are each equipped with two chain conveyor type coal feeders, designed for non-clogging operation with wet coal and quickly accessible by removing a plate on the front of the feeder casing. The shear pin is replaceable without tools. The feeder is cooled both by air passing through a chamber around it and by water cooling devices built into the casing. The feeder delivers coal to the overthrow rotor, which is of spiral construction to aid in complete distribution of coal over the grate. The traveling grate of the stoker is driven by a hydraulic drive unit, shown in the left foreground of Fig. 4. The grate travels toward the boiler front very slowly, since its function is to discharge the ash from the fire continuously. The ash drops to a hopper from which a vacuum ash conveyor system delivers it to a new outside ash storage hopper, Fig. 3.

Coal-Handling Equipment

Coal properly sized and prepared for the stokers is received in hopper bottom railroad cars and is weighed on railroad scales before being delivered to the plant. To unload a car, it is run into the end of the boiler house, where, if the coal is wet or frozen, it may be dried out as much as possible. Coal is dumped into a track hopper that loads it to a flight conveyor running in the ash tunnel of the old boiler house. The flight conveyor delivers the coal to a bucket elevator which elevates it to an overhead steel coal silo, large enough to hold 150 tons of coal. From this silo, the coal flows through suitable shut-off gates and chutes directly to the stoker hoppers and thence to the stoker feeders as described above.

Draft Equipment

Combustion air for the stokers is supplied to each by a motor-driven unit-mounted forced draft blower mounted in the back of the hopper below the stoker as shown in Fig. 5. Induced draft is produced for each boiler by an induced draft fan of 28,000 cfm capacity with dual drive by steam turbine and electric motor for heat balance adjustment. Ahead of each induced draft fan, a multiclone dust collector is installed to trap out fly ash before it can pass through the induced draft fan. The induced draft fans discharge the flue gas through new ductwork to the existing breeching and thence to the existing 6-ft by 115-ft steel stack.

The boilers are provided with dust

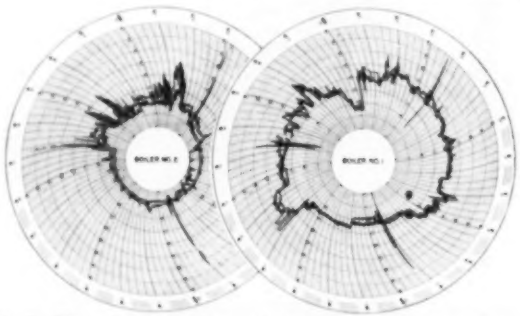

Fig. 8. Charts from Boiler No. 1 (right) and Boiler No. 2 (left) for typical winter day loads, showing wide steam load swings produced by steam hammers

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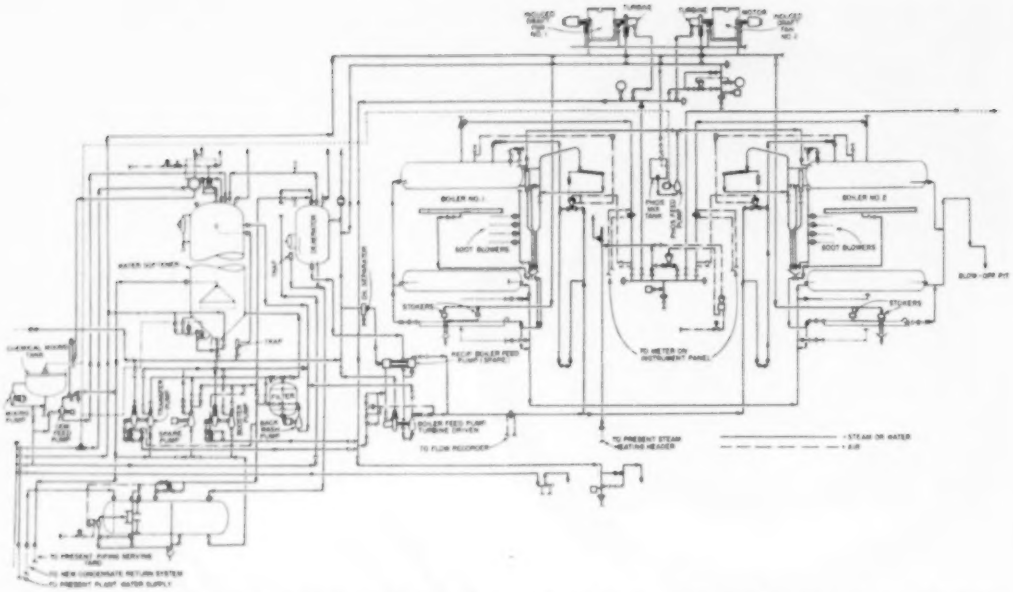

Fig. 9. Piping diagram of new Marion Power Shovel Co. boiler plant, showing how turbine driven auxiliaries supply steam for feedwater heating

collecting hoppers, and each of these hoppers, as well as the dust collector, discharges its fly ash to the reinjection system designed as part of the stoker installation. In that system, specially built visible feed ejector hoppers with Pyrex observation windows, ejectors and nozzles, all of alloy iron, are used.

The small, 1400-cfm turbo-blower at the right of Fig. 5 supplies air to the ejector under each fly ash hopper and from the ejector the air passes through a venturi, producing a pressure drop that sucks the cinders into the air stream and returns them to the furnace.

The above blower also supplies air for the overfire air injection nozzles located in the front wall of the furnace, and directed so as to produce turbulence in the furnace gases.

Combustion Control and Results

Combustion in these two boilers is automatically controlled by a Hagan automatic combustion control system centralized with the necessary instruments on the panel of Fig. 7 just in front of and facing the two boilers. The combustion control system, through suitable power drives, adjusts the coal feed to the load by operating the feeder speed adjusting quadrant on the spreader stokers, adjusts the forced draft blower speed to maintain the desired fuel-air ratio and varies the setting of the induced-draft fan dampers to maintain constant furnace draft. For each boiler, a multi-point draft gage, a Ring-Balance type steam flow airflow meter and the manual-automatic and transfer adjustors of the combustion control system are mounted on the panel.

The charts of Fig. 8 show typical load conditions on the boilers when the steam hammers are operating and producing instantaneous load swings of 13,000, 15,000 and in some cases as much as 20,000 lb per hr. Our records of coal burned and steam consumed show that the efficiency of these boilers runs slightly over 79 per cent with load at about half of rating, while tests show CO_2 from 13.5 to 13.8 per cent.

Feedwater Treatment

To supply feedwater for these boilers, a complete water treatment system was installed. The water source is water from deep wells and to prepare it for boiler feedwater, it is first passed to a 30,000 lb per hr lime-soda softener, then to a deaerating feedwater heater. It leaves the heater at 235 F and is pumped to the boilers by a 160-gpm centrifugal turbine-driven boiler feed pump. A reciprocating boiler feed pump from the old plant was retained as a standby unit. Steam for the deaerating feedwater heater is the exhaust from the various steam-driven boiler auxiliaries, as shown in Fig. 9, a schematic diagram of the boiler plant piping.

As shown on the drawings, the various boiler auxiliaries are driven by steam turbines, motors or dual drives in such a way as to provide steam required for building heating at 0 to 80 psi and for feedwater treatment and deaerating. The induced draft fans may be motor driven when their turbine exhaust steam is not required. Exhaust from the turbines driving the fans, boiler feed pump, water treatment plant pumps supplies the water softener and deaerator.

Condensate from the heating system and some closed process heaters is returned to the boiler house via a new condensate return system and is stored in a condensate storage tank, Fig. 9, from which the transfer and booster pumps deliver it to the deaerator.

Electric Power

As noted above, all electric power required by the Marion plant is now purchased. The old engine-generators of the plant, now removed, were formerly installed in an engine room adjoining the boiler room. This now contains the distribution switchboard but the power comes through a 13,800-v substation, (now being changed to 33,400 v) where it is stepped down to 2300-v for plant distribution systems.

In the old engine room are now installed three General Electric 500-kw motor generator sets, each driven by a 700-hp, 2300-v motor, for producing direct current for production machinery. Also in this old engine room are now installed two Chicago Pneumatic Tool Co. air compressors for supplying plant compressed air at 100 psi. Each of these is rated at 2618 cfm of air and is driven by a 450-hp synchronous motor that aids in power factor correction.

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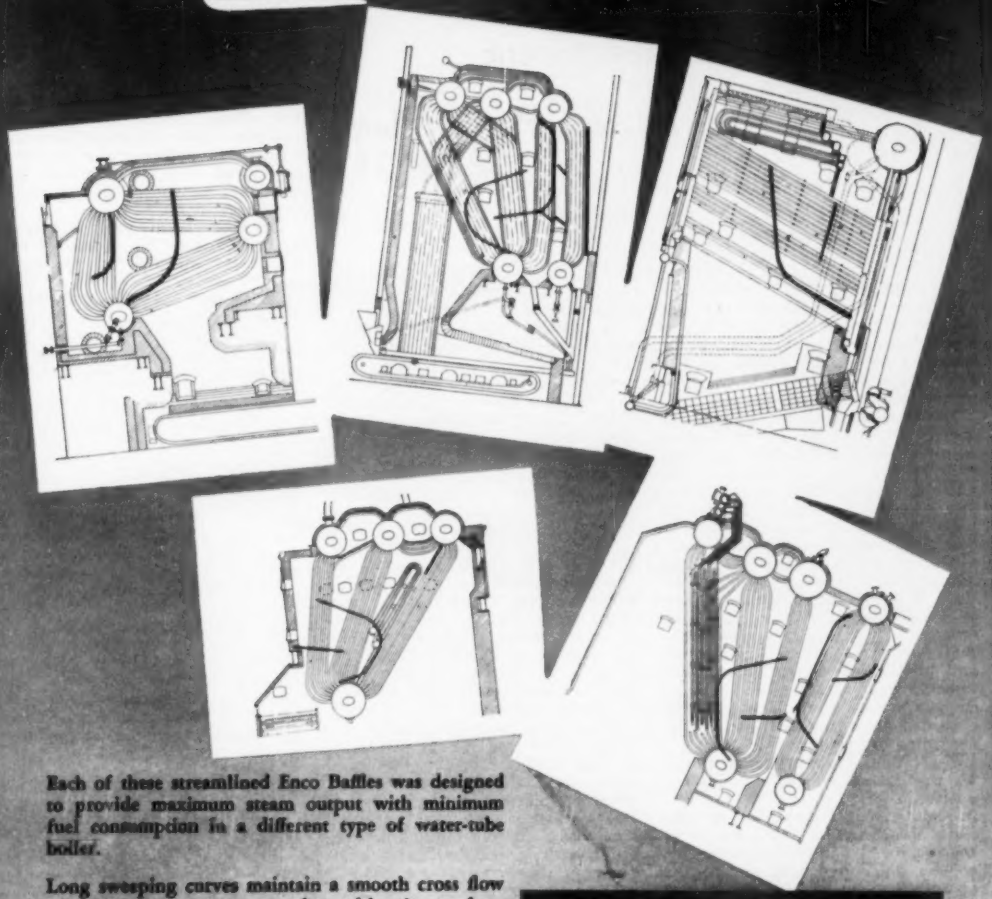

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ATOMICS

Instruments and Measurement in Atomic Power Plants

By D. COCHRAN and C. A. HANSEN, Jr.
Knolls Atomic Power Laboratory,
Schenectady, N. Y.

THE ATOMIC power plant now being constructed for the Atomic Energy Commission at the Knolls Atomic Power Laboratory in Schenectady will probably be the first to generate useful electric power in more than token amounts.

The possibility of *breeding* which is defined as the simultaneous production of new nuclear fuel at a rate greater than the fuel consumption, will also be investigated at this plant. The installation will use a liquid metal reactor coolant and steam electric power generation equipment.

The operation of this plant requires much elaborate instrumentation. Most of the instruments are standard commercial devices, as, for example, those on the steam turbine, electric generating equipment and auxiliaries. Others must meet unusual requirements, and special designs are required. These can be classified according to three groups according to function:

1. Operation. Instruments required for the control and safety of plant operation.
2. Maintenance. Instrument to observe the condition and behavior of the reactor structure, fuel elements, coolant and blanketing gas as the operation of the plant proceeds.
3. Health. Instruments required to monitor radiation leakage in the plant to insure protection of operating personnel.

In addition to requisite accuracy and sensitivity, a number of detection devices in atomic power plants must meet requirements not found in conventional power plant applications. These requirements arise from the radioactivity of the reactor and coolant and the shielding surrounding them.

One of the most important requirements is extreme reliability. It is essential that the nuclear reactor remain under control at all times. Ultra reliable controls have to be provided backed up by pyramided safety controls. These must be provided to "put out the fire" not blow off steam as can be done by safety valves on conventional boilers. There is nothing about a nuclear reactor that corresponds to a steam boiler in a conventional boiler plant. In such a plant when there is a sudden decrease in the rate of heat absorption by the turbine system, the extra energy in the boiler may be dissipated by blowing the safety valve. The nuclear reactor on the other hand has definitely limited capacity for absorbing or dissipating extra energy. The operating controls backed up by the safety controls must be able to decrease the rate of heat generation quickly enough to prevent overheating of the reactor even under the most abnormal fluctuations in connected load or failure of power conversion equipment. All instruments must be designed to *fail safe*, so that an instrument failure shuts down the plant.

Since it is not possible to perform direct inspection and maintenance work on the detecting devices in the radioactive zone they must be designed so they can be checked and calibrated remotely where necessary.

Pressure, temperature and flow detectors must function correctly in the presence of tremendous radiation. Thus, continued exposure to radiation must not cause such physical deterioration of the devices as to change their performance in a way that cannot be determined or compensated for.

Another requirement is absolute leak tightness. The escape of even a minute quantity of radioactive coolant or of blanket gas which might contain fission products should cause radiation monitoring devices to register requiring that the plant be shut down and evacuated until the leak could be located and repaired.

Because of the extreme difficulty and expense of replacing faulty detecting instruments, long operating life is much more important in these applications than is usually the case. There is great incentive to develop long-lived instruments and devices, and there is frequent justification for using more expensive devices to insure long service. A few situations exist where, once the reactor has been operated, detecting devices become absolutely inaccessible.

Operation of this first plant may be limited somewhat by inadequacy of instrumentation, but this first operating experience will direct attention to the most critical problems and probably will reveal limitations beyond these discussed here.

The above article is an abstract of an article in the January issue of ATOMICS Magazine.

The new ATOMICS represents a greatly expanded service to those who are interested in the theory and application of nuclear energy. It will keep readers abreast of what is happening in the field of atomic power development, in the industrial applications of radioactive isotopes, and in the use of nuclear energy in medicine, biology and agriculture. The January issue, in addition to the article abstracted on this page, contains other material of atomic interest including the eighth installment of the course in Nuclear Power Engineering which started in the June 1949 issue.

If you are interested in seeing this new magazine regularly, send in the attached coupon for a free copy. You will be under no obligation for this. ATOMICS will be published monthly, and as has been true of the articles which appeared in the ATOMICS section of Power Generation, the articles will be kept on a practical, understandable level.

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Questions and Answers

Q & A—THE POWER ENGINEER'S FORUM—HERE'S HOW IT WORKS

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Answer No. 451

SHOULD HE USE ACCUMULATOR ON LINES TO STEAM PRESSES?

TWO STEAM PRESSES in his plant, said W.R.R., December issue, have combined steam load varying from 2000 to 16,000 lb per hr over a 5-min. period. He also has a Corliss engine consuming from 7000 to 11,000 lb of steam per hr. Steam is generated by water-tube boilers.

Operation of the presses produces severe fluctuations in boiler water level and steam pressure and these prevent good boiler operation and affect both boiler and engine economy and power. In short, they rock the power house.

Can these fluctuations be smoothed out by installation of a steam accumulator on the steam lines to the press? asked W.R.R. Or are there other better methods of doing it. He said he could not find detailed data on design, construction, operation and costs of accumulators.

We referred him to the literature on the subject which was quite detailed and extensive some 20 years ago, also sent him a list of accumulator manufacturers who can supply construction details.

The steam accumulator was designed originally for just such applications as W.R.R. describes, to smooth out boiler operation when the steam load swings violently. It has been used for this purpose in many plants in Europe, where it was first developed. It has not been used so much in this country, but still there are relatively a good many installations here in paper mills, steel mills, breweries, gas plants, sugar mills and the like.

However, the application of the accumulator in this country has not been as widespread as it might have been, because the water-tube boiler in this country, together with its firing equipment, auxiliaries and automatic controls have been developed in such a way as to handle relatively wide load swings with safety and without too much sacrifice in economy.

Also, in many instances where swinging loads must be met, efforts have been made to re-schedule and change steam-consuming operations to smooth out the load itself, reduce peaks, raise valleys. Under the guidance of skillful power engineers, it is surprising how much can be done by management in this regard, when it is demonstrated that the fuel bill is affected. On the other hand, there are many cases in which it is impossible to smooth out the load or to modify existing water-tube boilers or install new ones that will handle it; and then an accumulator may solve the problem.

In a well-known gas plant, several steam-turbine driven blowers supply air to certain process reactors in which air inlet valves are snapped open all at the same time, at intervals depending on the production conditions. The demand for air goes from minimum to maximum very quickly; the steam-turbines driving the blowers draw 8,000 lb of steam per hr at minimum air consumption and this rises to 40,000 lb steam per hr in 11 sec.

Two small water-tube boilers, fired either by oil or by pulverized coal, supply the turbine steam at 250 psi. We have stood and watched these turbines pick up this load in 11 sec and the pressure gages at the turbines registered a drop of 10 psi as the load came on.

Another very good illustration of how modern spreader-stoker-fired boilers can handle a swinging steam hammer load, with swings as high as 16,000 lb in a few seconds, is given in this issue. See the description of the modernized steam plant of Marion Power Shovel Co. page 82.

Below are some interesting suggestions from Q & A readers.

Re-schedule Presses or Use Some Form of Thermal Storage, says Butcher

FIRST THING to do to help the steam pressure is to schedule the press operations, if possible, so the peaks of the presses do not occur at the same time.

Assuming the steam pressure at 260 psig and a pressure drop of 30 lb during the pressing cycle, there would be available about 11.6 Btu in each pound of water in the boiler for use in evaporating additional steam at the lower pressure. Each pound of steam released at the lower pressure would require 832 Btu to evaporate it from the liquid; hence it would require about 77 lb of water capacity in the boiler per pound of steam released due to pressure drop.

From the above, it looks like the storage capacity required in an accumulator might be too great to be economical. However, that will depend upon the capacity of the boilers, as well as on the demand.

A pressure tank connected in series with the top and bottom drums of the boiler, so the temperature of the water in the tank will closely follow that in the boiler, will have the same effect as an accumulator of the conventional type. Forced circulation might be required to make the tank temperature sufficiently responsive.

A horizontal tank on the main steam line, with the steam introduced along the bottom of the tank, would become an accumulator. Such a tank 8 ft in diameter could be expected to yield about 250 lb of steam per foot length per cycle. Design and installation of such a tank would require careful engineering or it would probably be a disappointment.

Due to its size, there would be considerable heat loss from the surface of the tank even with a good thickness of insulation.

Additional boiler capacity, with the boiler having a large water volume, may well be the best solution. Only a careful study will tell the story.

Cincinnati, Ohio IRA A. BUTCHER

An HRT Boiler Might Help says Holman

ASSUMING from the Editor's note that WRR has obtained all information he needs on steam accumulators, I would like to point out that such a steam storage vessel is not the only solution to his problem. Before installing it he should answer these two questions:

1. Is any expansion in steam generating equipment contemplated in the foreseeable future?

2. Will it be necessary soon to replace one or both of the present water-tube boilers?

If the answer to one or both of these questions is yes, then WRR should install an HRT boiler either

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Where is the money to be found? In the use of AMBERLITE IR-120—stable, high capacity synthetic resin exchanger now available in large quantities. Check the advantages listed at the left. Then write to Department PG-5 for technical literature that describes the resin in greater detail.

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as replacement or addition. This type boiler has a much greater water reserve of steam than the water-tube type, and of course yields much more usable steam per psi pressure drop on jerk loads such as that described. There is also greater steam separating surface in the fire-tube boiler, and flashing of water into steam on pressure drop is less likely to carry over water and prime an engine.

I once knew of a mining company that installed water-tube boilers to supply steam to a hoisting engine. Like the duplex steam pump, this engine has no inertia reserve in a flywheel, and a full head of steam without expansion is required to move the piston from one end of the cylinder to the other.

In this case the pressure fell from 200 psig to 125 psig, and even lower, under prolonged hoisting operations. Foaming was pronounced, with frequent damage to tubes. An old HRT boiler, which the water tube boilers had been installed to replace, had to be put back into service as an absorber for shock loads.

Moral: Install fire-tube boilers for shock loads.

Decatur, Ill. GEORGE HOLMAN

Answer No. 452

HOW DO YOU TEST A LADDER?

IN THE December issue, E.H.H. asked readers to advise the best method of testing a wooden ladder. Here are a few of the many replies to this very important question.

Frequent Inspection Needed; Tests May Weaken Ladder, says Freyberg

E.H.H. will probably be told about the "four-man" test and other loading tests for the specific purpose of determining ladder safeness. This type test has come to be considered far more dangerous than no test at all, since there is more probability of weakening a good ladder than there is of finding defects in a weak ladder. Therefore, E.H.H. would do better to make close visual inspections of his ladders at frequent intervals; and, to facilitate such inspections, he should insist that none of his ladders be painted with anything but clear varnish as a preservative.

The most helpful suggestion is to start off with a good quality ladder, for instance, one which meets the specifications of the American Standards Association (70 East 45th St., New York City) in their Safety Code for Wood Ladders. I have only the 1934 Code, which specified such things as permissible size of pitch pockets, length and depth of checks, size and location of knots, and permissible maxima in angle of grain in side rails and rungs. I understand that there is a 1948 revision of this Code which can be procured from the A.S.A. for 50 cents.

Pleasantville, N. Y. RICHARD H. FREYBERG

You Don't, says Rossnagel

IN REPLY to Question 452, "How Do You Test a Ladder?" my answer is "You Don't." Load testing of any object or structure made of wood is extremely treacherous unless the test is scientifically conducted, for there is far greater probability of damaging a good ladder, scaffold plank, beam, etc., than of detecting a defective one.

We do, under certain special circumstances, permit the load testing of questionable scaffold planks, in which case the stress, deflection, etc. are mathematically determined in advance. This is practicable as all our scaffold planks are of the same dimensions and material. Inasmuch as ladders vary in length, cross-section, and material, it would be necessary to develop scores of test procedures, and the chances of error in the test are very great.

Hence, rely only upon a very thorough visual inspection.

You might refer to the "Handbook of Rigging."

New York City W. E. ROSSNAGEL

Ladder Test by Weight

PUT YOUR ladder horizontally across two saw-horses, boxes or other support you have, with each support at the end of the ladder. Lay the ladder flat and then walk over the top of the rungs. If the ladder stands this test without breaking, it is safe to use anywhere.

St. Paul, Minn. ERNEST WEIGT

How to Test and Inspect—Butcher

MAXIMUM BENDING MOMENT that ordinarily occurs on a ladder is found when it is in a horizontal position, with a concentrated load in the center, as when it is used for scaffolding. Therefore, by supporting the ladder at each end, a short distance above the floor and standing in the middle of it, any employee can quickly determine if its side supports or rails are safe. If it deflects excessively, discard it.

Wooden ladders ordinarily have one of three types of rungs: round turned hardwood fitted into holes bored in the side pieces; flat slats nailed into notches in the edge of the side pieces; and flat slats nailed onto the edge of the sides.

The first type is the common factory-built, commercial ladder. The rungs of this type usually need only visual inspection, though sometimes season cracks may indicate a load test.

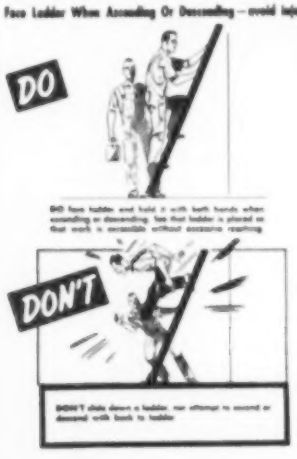
Ladders having flat or slat type rungs should be carefully inspected to make certain that the rungs are not split or loose at the nailing point, for this is usually their weakest point.

All ladders should have abrasive or antislip shoes and these should be checked to see that they are in good order.

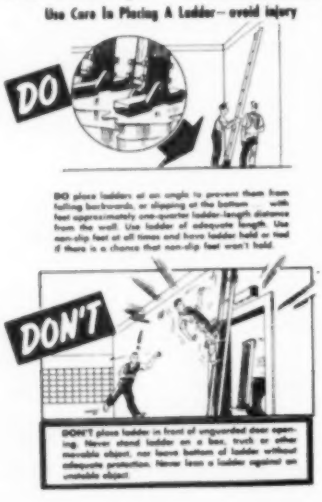
If the ladder is of the extension type, the irons that secure the two sections together should be inspected to see that they are not bent, broken or loose at their connections.

The above does not mean much

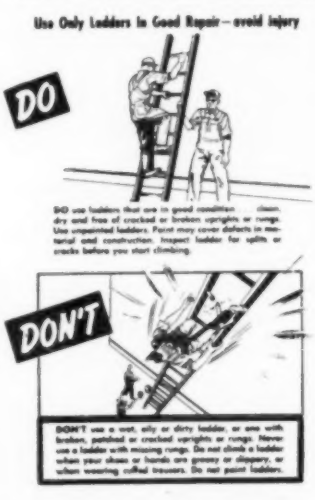
Face Ladder When Ascending Or Descending—avoid injury


DO
DON'T
DO face ladder and hold it with both hands when ascending or descending. Be that ladder is placed so that work is accessible without excessive reaching.
DON'T slide down a ladder, nor attempt to ascend or descend with back to ladder.

Use Care In Placing A Ladder—avoid injury


DO
DON'T
DO place ladders at an angle to prevent them from falling backwards, or slipping at the bottom — with feet approximately one-quarter ladder-length distance from the wall. Use ladder of adequate length. Use non-slip feet at all times and have ladder held or tied if there is a chance that non-slip feet won't hold.
DON'T place ladder in front of unguarded door opening. Never stand ladder on a box, truck or other movable object, nor leave bottom of ladder without adequate protection. Never lean a ladder against an unstable object.

Use Only Ladders In Good Repair—avoid injury


DO
DON'T
DO use ladders that are in good condition — clean, dry and free of cracked or broken uprights or rungs. Use unpainted ladders. Paint may cover defects in material and construction. Inspect ladder for splits or cracks before you start climbing.
DON'T use a wet, oily or dirty ladder, or one with broken, patched or cracked uprights or rungs. Never use a ladder with missing rungs. Do not climb a ladder when your shoes or hands are greasy or slippery, or when wearing cuffed trousers. Do not paint ladders.

Use Ladder Alone And Avoid Excessive Leaning – avoid injury
DO
DO arrange to have only one man onto ladder at a time. Use additional ladders, or erect a scaffold if others must work with you on a job.
DON'T
DON'T permit others to mount ladder while you are on it. Do not lean so far from either side of ladder that you will lose your balance and fall . . . move the ladder.

unless inspection is made at regular intervals, of all ladders in the plant, the length of the intervals depending upon the frequency of use of the ladders.

Most important safety factor is to develop safety consciousness among the workmen so that they will not use a ladder while it contains a visible defect.

Cincinnati, Ohio IRA A. BUTCHER

Inspection is the Thing, Reynolds Points Out

WITH FALLS causing approximately 30 per cent of all accidental deaths and ranking second only to motor vehicle accidents as Old Man Accident's chief helper, the testing and inspection of ladders is of utmost importance.

Space will not permit a complete answer to E.H.H.'s request. However, booklet A14.1-1948 entitled American Standard Safety Code for Wood Ladders, covering construction, care and use of ladders gives the complete information. The booklet may be obtained for 50 cents, direct from American Standards Association, 70 East 45th St., New York 17, N. Y.

We use most of the practices described in that booklet around our plant and our strongest and most rigidly enforced safety rule provides that *"employees should inspect each ladder before using it,"* and *"a routine inspection should be made of all ladders once every six months,"* and *"ladders in daily use should be checked as used and inspected every thirty days."*

Here are the important points of our ladder inspection routine:

(1) Check for cracked or broken uprights or rungs. Rungs and uprights should be clean, dry and free of splits or cracks.
(2) Check ladder for wet spots, oily spots, dirt, and splattered paraffin or solder.
(3) Use only unpainted ladders; paint may cover defects in

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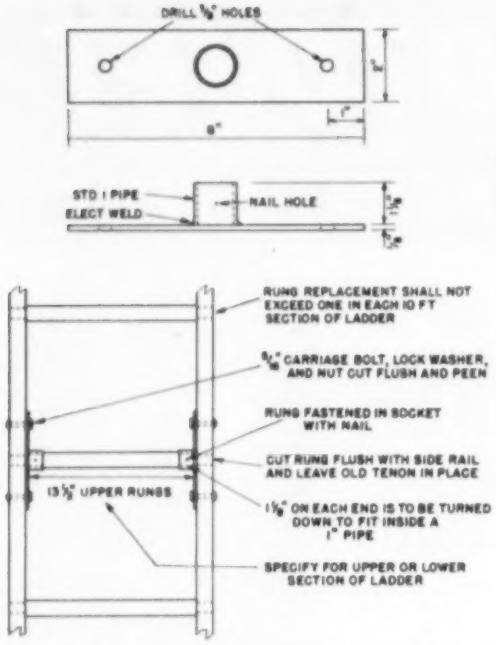

DRILL ⅝" HOLES
8"
STD 1 PIPE
ELECT WELD
NAIL HOLE
RUNG REPLACEMENT SHALL NOT EXCEED ONE IN EACH 10 FT SECTION OF LADDER
⅝" CARRIAGE BOLT, LOCK WASHER, AND NUT CUT FLUSH AND PEEN
RUNG FASTENED IN SOCKET WITH NAIL
CUT RUNG FLUSH WITH SIDE RAIL AND LEAVE OLD TENON IN PLACE
13 ½" UPPER RUNGS
1⅛" ON EACH END IS TO BE TURNED DOWN TO FIT INSIDE A 1" PIPE
SPECIFY FOR UPPER OR LOWER SECTION OF LADDER

Fig. 1. Details of rung replacement socket for wood ladder, as used by one utility company

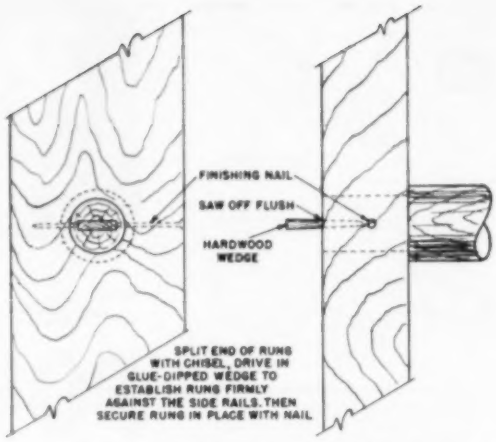

FINISHING NAIL
SAW OFF FLUSH
HARDWOOD WEDGE
SPLIT END OF RUNG WITH CHISEL, DRIVE IN GLUE-DIPPED WEDGE TO ESTABLISH RUNG FIRMLY AGAINST THE SIDE RAILS. THEN SECURE RUNG IN PLACE WITH NAIL

Fig. 2. Method of wedging rungs on a wood ladder, as used by one utility company

materials or construction.

(4) Check for missing rungs.

(5) Check the rope on extension ladders; make sure it is not frayed or worn.

(6) Check the locks and pulleys on extension ladders; make sure they are fastened firmly to the ladder.

Those are a few of the important points. If we had the space I would like to present all of the tests described in the American Standards' booklet. However, the above tests are the important ones and can serve as the basis for establishing a regular routine of ladder inspection. And if you want to go a step further, the accompanying illustrations on ladder safety will be a big aid in teaching your employees to use ladders safely. These illustrations are reproduced through the courtesy of the Division of Labor Standards, U. S. Department of Labor.

Chicago, Ill. JOHN G. REYNOLDS

Inspection Rather Than Test, says Miller

I HAVE NEVER heard or read of a test for ladders aside from a thorough inspection. This would include examination for loose or worn rungs, cracked, split or broken side rails, need for recoating, damaged extension parts, splinters, decay and condition of ladder shoes.

I would like to suggest, however, that E.H.H. obtain a copy of the American Standard Safety Code for Wood Ladders from the American Standards Association, 70 E. 45th St., New York, N. Y. and I feel sure that if there is a definite test for ladders the Code will give it.

Alton, Ill. LOUIS B. MILLER

Inspection, Rather than Test, says Hasskarl

I DO NOT KNOW of a method for testing ladders. We do not approve of testing wood used in ladders and similar tools as it weakens it, which may result in the tested article breaking when it is in actual use.

When inspection and examination shows that a ladder may be weakened due to normal wear, or is defective due to loose rungs or split side rails or gouged side rails or deep indentations in the rungs or side rails, we either repair or destroy the ladder.

Allentown, Penna. P. L. G. HASSKARL

Selected portions of a utility company's operating instructions covering use, inspection, and care of ladders

CLASSIFICATION

1. Ladders used in company work are classified as Fixed, Portable, Portable Step, Extension, Mason and Aluminum.

(a) Fixed ladders include all ladders, wood and metal which are permanently fastened to a structure.

(b) Portable ladders include all ladders (straight type) with but one section.

(c) Portable step and platform ladders include all ladders with flat steps so constructed as to be self-supporting.

(d) Extension ladders include all ladders of two or more parallel sections traveling in guides so arranged that they may be adjusted to variable lengths.

(e) Extension Trestle portable ladders include two parts, each equivalent to a straight ladder linked at the top with spreaders similar to a stepladder. This type of ladder is used to support planks.

(f) Sectional ladders include two or more sections so constructed that the sections pyramid. This type of ladder is used by window cleaners.

(g) Aluminum, magnesium and similar ladders include portable, straight, extension and scaling types.

(h) Mason's portable cleat ladders, made locally and used in excavations. Restricted to 16 ft in length, the dimensions of side rails and cleats shall be as follows:

1. Side rails 2" x 4" shall be of straight grained northern spruce or the equivalent in strength.
2. Knots ½ in. or less in diameter will be permitted, but shall not be nearer than 1 in. to the edge of the side rail or 3 in. to the cleat.
3. Cleats ⅞ in. x 3 in. shall be of straight grained, white ash or the equivalent in strength and wear, and free from knots
4. They shall be housed in the rails ½ in. and fastened to each rail by two ten-penny nails and one ¼ in. throughbolt made flush with the surface of the cleat.
5. The cleats shall be spaced uniformly 12 in. apart. Shorter spacing is permissible, but it shall not be less than 8 in.
6. The inside width of the ladder shall be 18 in. at the top and 21 in. at the bottom.

INSPECTION

2. All new ladders before being accepted by storekeeper or other employees shall be checked for dimensions and quality to conform with state Department of Labor and Industry Regulations for Ladders.

(a) All ladders shall be inspected by foremen or workmen before they are used.

(b) Ladders with split or gouged side rails, loose rungs or defective locks or other parts shall not be used.

USE

3. Use of ladders shall be governed by the following:

(a) All portable, straight and extension ladders shall be equipped with notched wheel feet, except as noted in Sub-paragraph (b) following.

(b) Ladders used indoors or at other locations where notched wheels will damage the surface on which the feet are placed, may be equipped with non-skid type of feet upon approval of the Head of the Department and the Safety Department.

(c) Ladders shall be set up so that the horizontal distance from the bottom of the ladder to the support is one-fourth the length of the ladder. If this cannot be done, the ladder shall be tied or otherwise fastened in position.

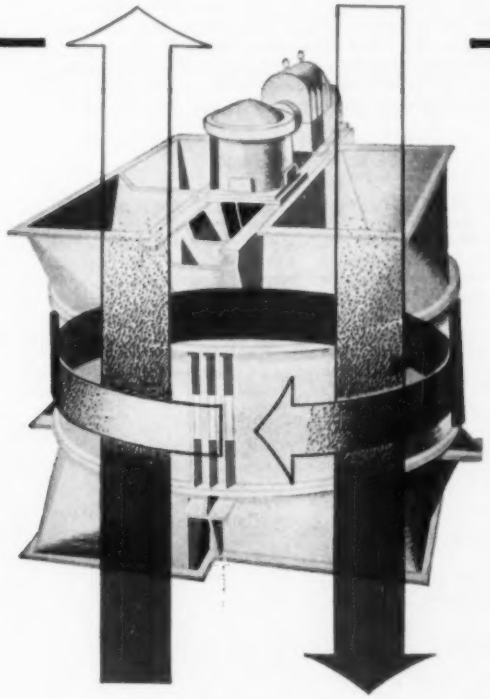
(d) Ladders used in a heavy wind shall be fully tied and braced.

(e) The rope with which the top section of an extension ladder is raised and lowered

more than 160,000,000 lbs/hr of post-war steam generating capacity

equipped with *Ljungstrom*

AIR PREHEATERS



Here indeed is impressive evidence of the wide acceptance of the Ljungstrom air preheater. Since the war the total capacity of steam generating units equipped with Ljungstrom air preheaters, installed, under construction or on order in industrial and utility plants throughout the country comes to well over 160,000,000 lbs of steam per hr.

The reasons for the steadily increasing preference for the Ljungstrom air preheater are simple enough. The continuous regenerative counterflow principle assures maximum heat transfer with minimum weight and size. Flexible and compact, it may be used in a wide range of applications. Its proven reliability and low maintenance eliminate costly shutdowns.

If you are planning to build a new plant or modernize an old one, investigate the possibilities of the Ljungstrom. The specialized experience of Air Preheater engineers is at your disposal, to aid in effecting the most economic heat recovery from flue gases.

The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves the heat is transferred from the waste gases to the incoming cold air.

THE AIR PREHEATER
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CORPORATION

shall be tied securely around a rung of the lower section of the ladder while the ladder is extended.

USE OF SAFETY STRAP WHILE WORKING ON LADDERS

4. Standard practices to be followed in the use of safety straps by men while working aloft on ladders are defined as follows:

(a) When a metal or wooden ladder is permanently attached to a building or support, the men working aloft on it may use a safety strap.

(b) When a ladder is placed against a building or another safe support and it is securely fastened with rope slings to the support, the man working aloft on it may use his safety strap.

(c) When a ladder is placed against a building or another safe support and it cannot be securely fastened to a support, the man working aloft on the ladder shall not use a safety strap.

(d) A workman on an unattached ladder shall support himself by putting one leg over a rung of the ladder so that the back of the knee joint is firmly against a rung of the ladder.

(e) House service brackets or racks shall not be used as supports for ladders.

CARE

5. To insure safety and serviceability, the following precautions on the care of ladders shall be observed:

(a) Ladders shall be maintained in good condition at all times; the joint between the steps and side rails shall be tight, all hardware and fittings securely attached and the movable parts shall operate freely without binding or undue play.

(b) Metal bearings of locks, wheels, pulleys, etc., shall be frequently lubricated.

(c) Frayed or badly worn rope shall be replaced.

(d) Safety feet and other auxiliary equipment shall be kept in good condition to insure proper performance.

(e) Ladders shall be stored in such a manner as to provide ease of access for inspection and to prevent danger of accident when withdrawing a ladder for use.

(f) Wood ladders, when not in use, shall be stored at a location where they will not be exposed to the elements but where there is good ventilation. They shall not be stored near radiators, stoves, steam pipes or other places subjected to excessive heat or dampness.

(g) Ladders stored in a horizontal position shall be supported at a sufficient number of points to avoid sagging and permanent set.

(h) Ladders carried on vehicles shall be adequately supported to avoid sagging and securely fastened in position to minimize chafing and the effects of road shocks.

(i) Ladders shall be kept coated with Clear Varnish, Company Catalogue No. 715-070. Where used or stored outdoors, annual treatment is required. This does not preclude more frequent treatments when necessary.

(j) Ladders shall be inspected frequently, and those which have developed defects shall be withdrawn from service for repair or destruction. Ladders tagged or marked as "Dangerous—Do Not Use" shall not be used until they are repaired.

(k) Rungs shall be kept free of grease and oil, and metal rungs should be suitably roughened to prevent slipping.

REPAIRS

6. The extent to which it is economical to repair damaged or defective ladders requires good judgment, with respect to cost of new ladders versus cost to repair old ones.

(a) The tightening of loose rungs, steps, bolts and rivets and the replacing of worn ropes, defective locks and safety feet are economical.

(b) The tightening of rungs shall be done in accordance with Fig. 1.

(c) The replacing of broken rungs shall be done in accordance with Fig. 2 of this instruction. (The replacement of rungs by this method shall not exceed one rung in each 10-ft section of a ladder.)

(d) The replacement of side rails of wooden straight, extension, extention trestle and section ladders should only be done when the other side rail and other parts are in good condition.

(e) Repairs to aluminum, magnesium and similar ladders shall not be made without the specific approval of the Superintendent.

7. DEFECTIVE, DAMAGED OR BROKEN LADDERS UNFIT FOR FURTHER USE OR REPAIRS SHALL BE DESTROYED. LOCKS, SAFETY FEET AND SIMILAR PARTS IN GOOD CONDITION SHALL BE REMOVED BEFORE THE LADDER IS DESTROYED.

PRESERVATIVE

8. Use Clear Varnish, Company Catalogue No. 715-070, cut 50% with thinner for the first coat. Then apply three coats of varnish, at received consistency, to all wood and metal parts. Allow the varnish twenty-four hours to dry between each coat. If the finish of the ladders is rough following the application of the first coat of cut varnish, remove all rough spots and splinters by rubbing them lightly with fine sandpaper.

9. All metal parts, if not newly galvanized, shall be painted with one coat of Black No. 715-012 after applying first coat of varnish to the wood.

10. Boiled Linseed Oil may be used to preserve ladders in plants and similar locations when, in the opinion of the superintendent, this preservative is desirable.

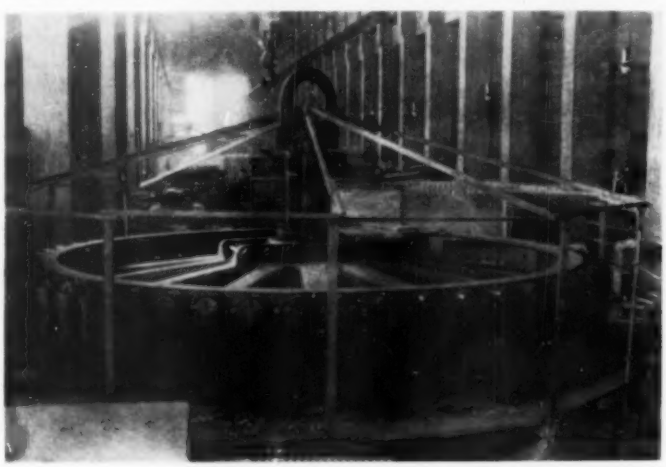
Shrink Links and Bolts in Power Plant Erection

Large slow-speed hydroelectric equipment still makes use of shrink links and bolts. Unless these are properly heated and set, they may cause dangerous stresses. In this article, Mr. McDermid draws from his vast and prolific experience in citing several interesting cases to show the necessity for extreme care in this phase of power erection work

By H. B. McDERMID

IT MIGHT BE THOUGHT that, because of the trend toward high speed units and the consequent reduction in size of rotating parts of modern power plant machinery, that the necessity for manufacturing flywheels in sections to permit shipping to the job had passed into the limbo of forgotten things, and with them the need for heavy bolts and shrink links to hold the sections rigidly together in the erected machine. But water power is still being used, with sometimes low heads, which necessitate low shaft rpm which in turn require large rotor diameters to enable enough pole pieces to pass a given point in a given time to produce the standard frequency of the alternating current.

So, in certain large machines the necessity still exists for cutting up



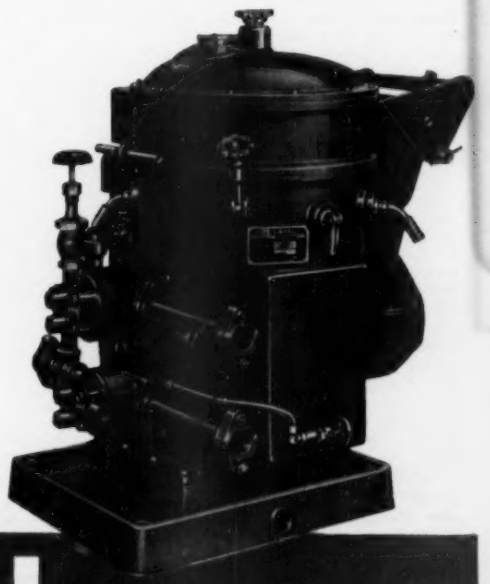
Rotor of a slow-speed hydro-electric generator, the two halves of which are fastened on the shaft by means of bolts

I STOP TROUBLE before it STARTS!

"I am De Laval Centrifugal Force. I am expert at removing dirt and water from lubricating oil — either turbine lube or Diesel lube. And because dirt and water are the chief causes of lubricating oil deterioration, I actually guard your power plant against trouble. I stop trouble where it counts — ***before*** it happens."

De Laval Centrifugal Force does its job thoroughly. The water is continuously discharged after being removed from the oil by centrifugal force, and the dirt is stored in the bowl, outside the zone where purification takes place.

De Laval Oil Purifiers offer still another advantage to plant operators — these machines have enough reserve capacity to take care of a sudden emergency, such as a surge of water due to a leak.



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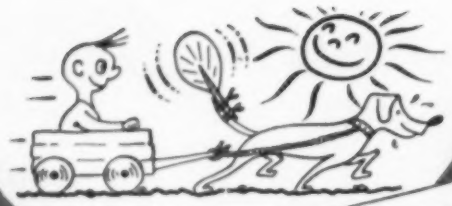

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and left for the contracting metal to finish the job; when all twelve bolts were so placed in that hub it was a safe bet that it would stay where placed. The engineers figured that had we been able to do this work without any loss of heat before the bolt was placed, that the contraction strains would have been about 95 per cent of the elastic limit of the steel; but of course, some heat had to be lost, even though the gang worked to their limit of speed and took pride in their record, so that, as a practical matter, there was delay enough and heat loss enough so that there had to be even a greater margin of safety than the computations showed.

Erecting a Rubber Mill

Sometimes conditions arise that do not permit of so careful heat treatment. One occurred in a rubber tire plant on some so-called "French presses." Here again were 4 in. diameter bolts, some 16 feet long holding both top and bottom castings of the press in place, each piece being gripped between a shoulder on the bolt and the nut at either end.

The designer had left no room at the bottom end to work a wrench and sledge, and no make shift could be found that would properly set up those lower nuts so the bolts and press would stay in place for long. There was no end wrench for the job, and no lifting device for handling the bolts.

Temporary tackle removed the upper casting, and each bolt in turn, hoisted till its lower end just entered the hole in which it belonged. Then a large kerosene torch was played on the bolt, between the lower shoulder and the end, heating it slowly to a mild temperature, judged by the colors shown on a previously brightened spot on the bolt side. Then the bolt was lowered into its place and the previously heated nut spun on by hand, then tightened against the casting by means of a sledge and punch, as best it could be done. Not a scientific job, but it proved effective; where the best cold job we could do, lasted two or three weeks, none of the heat tightened bolts was ever known to loosen at all, or give any other sign of trouble.

Nevertheless, the boiling water treatment is to be preferred, where ever practicable, as there is no need for unusual care to prevent overheating, and consequent damage from that source. If a steam jet were available, it could also be used to heat the bolts and would have very much the same factor of safety, as its greatest heat at atmospheric pressure could not exceed the upper limits desirable, while any kind of flame heating depends very much on the care and skill of the operator.

What Is Engineering?

By C. H. MORROW

The following comments on this subject were made recently to a group of high school students in connection with a program of advisory guidance sponsored by a local Kiwanis Club. The author is chief plant engineer of J. I. Case Co. and is well known to power engineers through his work in developing the power plants of his company and particularly in securing the boiler operation and performance detailed in his article, New 100,000-lb-per-hr Boiler Saves $100 a Day in Fuel, *Power Plant Engineering*, June 1944. Mr. Morrow's comments are particularly interesting in relation to the ideas expressed in the unusual article A Laborer's Criticism of Engineering Education by T. L. Bourbonnais, November 1949 issue and the comments thereon by George Holman and C. O. von Dannenberg, January 1950 issue.

WHAT IS ENGINEERING? It is a profession frequently confused with a Trade.

A profession is a calling in which one professes to have acquired some special knowledge, used by way either of instructing, guiding or advising others, or of serving them in some art.

A trade is a pursuit requiring manual or mechanical training and dexterity.

Over 2600 occupations carry the title of Engineer in the United States, most of which are a trade and have nothing to do with true engineering.

The engineering profession is said to be an art founded on scientific principles of the fundamental sciences—an art utilizing the forces of nature for the benefit of man.

Natural philosophy, which embraces all the fundamental laws of nature, can be taught in school, but the "art" must be developed and acquired by practice and experience. This experience begins when one is quite young, and continues throughout one's progressive lifetime of work.

What Is Success?

The most universal goal in life is an indefinite something called "Success." There is no universal formula for success in the field of engineering, nor in any other field, for that matter. Most famous and outstanding professional men did not at the outset seek any abstract final success, but simply sought to find the work that suited them best. A good example of what I mean is the case of Diderot, the great French encyclopedist. As a youth all he could say to the question of what he wanted to be was—"Nothing!" Yet, a few years later, he was full of devouring energy, and many of the lines of thought and action he helped to open up are those we follow today. He was a success, yet there is not the slightest evidence that he made it in any personal sense his aim.

The art of engineering is a jealous mistress, requiring a detachment from all things except the particular work of the moment. One who enters the field of engineering because he loves the work so much he can do nothing else is on the highroad to success. A job well done will be the reward to him—the material and monetary rewards incidental.

Engineering Aptitudes

Before taking up engineering it is important that the individual determine as far as possible if he is constitutionally suited to this work—whether he possesses the inborn aptitudes and will-power to attain the art. Anyone of average intelligence can get an engineering education, but not everyone has the natural engineering ability to apply the fundamental principles of science to practical uses. This ability must be inborn and cannot be obtained in school.

In addition to a high degree of mental ability, the successful engineer must have still more of a concentrated and self-possessed will-power that is impervious to external hindrances and able to work underground constantly toward the final objective. Imagination is essential to the good engineer. Behind every engineering undertaking is a man, or group of men, in whose imagination the entire project, from the conception of the idea to the final completion, was worked out.

We have come to think of engineers as being all college graduates, but a degree is not absolutely essential to success as an engineer. I think it was the Brookings Institution that made a survey of most of the industrial companies in the United States and found that the top engineer in more than half the cases was not a graduate. This is amazing but true. The report said, however, that these men believed they could have been better engineers if they had college degrees.

Engineering Opportunities

What about opportunities? In spite of the fact that many potential engineers graduate from colleges all over the land, there is a tremendous demand for good men. The interesting thing about the answer to this need is not the number of engineers but the amount of ability. Names on the payroll do not fill the need.

Industry in general is seeking men with broad fundamental training, imagination, wide perspective and sound reasoning capacity, and in my opinion the demand will continue to increase in the future, regardless of the number of graduates turned out by colleges.

NEW USES OF FLY ASH MAY ELIMINATE COSTLY DISPOSAL PROBLEM

NEW DEVELOPMENTS in the use of fly ash which promise to solve a disposal problem that saddles privately owned utilities with an investment in collecting equipment rapidly approaching $60,000,000, were outlined at the 70th annual meeting of ASME.

New uses for the ash, which is the residue from the burning of pulverized coal, were described during a symposium by prominent power plant research engineers. The results of a survey of all the principal consumers of pulverized coal in this country were given by Henry S. Walker, director of research for The Detroit Edison Co. During 1948, he said, over $1,000,000 was spent in disposing of 1,500,000 tons of collected fly ash by companies consuming over 65 per cent of the pulverized coal burned, with the cost expected to increase by 50 per cent in a year or two.

Privately-owned utilities have at present an investment of approximately $30,000,000 in equipment to collect fly ash and this figure will increase shortly to $60,000,000 with the further installation of collectors in existing and new power plants. Except for a very small portion, he added, the collected ash remains a nuisance for the operating company to dispose of without much aid from sale. He said dumping is usually the principle means of getting rid of it, but adjacent dumping grounds are not always available.

Soil Stabilization

Most recent application for fly ash, giving great promise of providing a real market, is its use in the field of soil stabilization, with particular emphasis upon road construction, declared M. C. Randall, senior engineer, Philadelphia Electric Co. A mixture of limestone screenings, fly ash and a small amount of hydrated lime has been developed at Philadelphia Electric for use as a base course for supporting a concrete pavement and as a cementatious fill to replace the customary limestone screenings normally used as the base course for bituminous concrete pavement.

A number of experimental installations of this type construction have been made, but as yet these installations have had insufficient service to definitely prove its superiority over standard construction. Installations of Cor Crete, as its is tentatively termed, have been made, utilizing it as the wearing surface on parking lots, driveways, walkways and the like, with every indication it is admirably suited to use.

Cost-wise, said Mr. Randall, it should be relatively inexpensive,

See Stack Dust Collection and Disposal, by P. W. Thompson; *Power Plant Engineering*, October, 1947, page 108.

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running in the neighborhood of crushed stone.

"If this one product alone develops and becomes a part of state road specifications the demand could without too great a stretch of imagination exceed the local fly ash production," he declared.

Insulating Cements, Building Brick

Other fly ash applications described were its use in insulating cements, building brick and in steel foundries to provide hot strength for core and molding sand, as a replacement for silica flour. It will do the same work as silica flour, he said, and in some instances work even better in the case of larger castings.

When used in the making of cement, a remarkable lack of shrinkage was noted when the cement had dried, and there was excellent adhesion to base insulating materials, said Mr. Randall, adding that the workability was found to be good and coverage equal if not somewhat better than the present commercially available cements.

"It was also found, that due to the high adhesion and low shrinkage, a single coat could be applied without the use of wire mesh reinfocement. Further, paint could be applied directly to the furnishing cement without the usual canvas jacket," he said. This cement will successfully withstand temperatures up to 1700 F, he said, permitting its use for turbine insulation.

Walter N. Handy, sales manager, Combustion By-Products Co., of Chicago, described the use of fly ash in concrete as a part of the cementing material. Laboratory tests and field experience, he said, show the following advantages: reduced temperature rise, reduced thermo and drying shrinkage, increased workability, resistance to freezing and thawing, resistance to sulphate attack and additional gain in strength at later ages. He said fly ash is presently being used in a large dam, several paving projects, a large sewer and several power generating stations.

The procedure used by the Detroit Edison Co. in developing the use of fly ash in the bitumastic road industry was outlined by C. M. Weinheimer, head of the mechanical division for that company. He said 31,200 tons of fly ash were sold by Detroit Edison in 1946 for use as a mineral filler in bitumastic road construction.

New ENGINEERING BOOKS

Cosmic Ray Physics. By D. J. X. Montgomery. First edition. 6½ by 9¼. 370 pages, illustrated, cloth. Published by Princeton University Press, Princeton, N. J., 1949. Price $5.00.

From all directions in outer space the primary radiation impinges on air molecules at the top of the earth's atmosphere, at the rate of about one particle per square centimeter every three seconds at latitudes far from the equator, and at about one-tenth this rate near the equator. The intensity does not vary with time by more than a few tenths of a per cent. The incident particles, presumed to be protons, range in energy from a few billion electron volts up to possibly 10^{20} electron volts. Every second of every minute, every hour, day after day, year after year, century after century, they come, never stopping, never ceasing. These are the cosmic rays. Where they come from no one knows, nor why, but for some fifty years, now, they have intrigued men's minds and today, they are the subject of world-wide investigation.

During the last two decades a great deal have been written about these mysterious rays, many theories have been advanced to account for their existence. These rays represent the highest concentrations of energy that we know in the universe. Our most powerful accelerating equipment cannot even approach the energies of these rays which come to us from outer space. An interesting photograph shows what happens when one of these particles hits the nucleus of an atom. This picture, appearing in Mr. Montgomery's book, shows the almost complete disintegration of a silver nucleus in the photographic emulsion of a sensitive plate. In this "star" there are 34 visible tracks, primarily protons and alpha particles. The total energy of all the emitted particles probably exceeds 1000 Mev.

The particular value of the excellent book lies in the fact that between its covers is presented an up-to-date survey of the entire field of cosmic ray studies. Its intention is to afford a student an opportunity to gain expeditiously a knowledge of this specialized field sufficient to provide an overall view of the subject and to help him in his study of the literature on the subject. While the emphasis is on the experimental aspects of cosmic ray technique, it is not a handbook for the laboratory. Little description of electronic circuits or equipment is included. Nor is it definitely historical; a considerable amount of historical material is included, this data is representative and in no way intended to be exhaustive. It is, however, an excellent survey and there is much in it to indicate promising lines of attack for the future.

Dr. Montgomery is now conducting cosmic ray research at the Aberdeen Proving Ground in Maryland. He has specialized in cosmic ray work for many years and during the writing of this book consulted with leading workers in the field.

COMING EVENTS

BCRI—The Bituminous Coal Research, Inc. will hold its annual meeting at the Netherland Plaza Hotel, Cincinnati, Feb. 9.

PEA—The Joint Mid-Winter Meeting of the Prome Movers and Electrical Equipment Committees of the Pennsylvania Electrical Association to be held at the Robert Treat Hotel, Newark, N. J., Feb. 23-24.

NPE—The National Production Exposition to be held at the Hotel Stevens, Chicago, April 4-8.

MPC—The twelfth annual Midwest Power Conference will be held at the Hotel Sherman, Chicago, April 5-7.

ASME—The Spring Meeting of The American Society of Mechanical Engineers will be held at the Hotel Statler, Washington, D. C., April 12-14.

AIEE—American Institute of Electrical Engineers to hold its Power Conference at the Wm. Penn Hotel, Pittsburgh, April 19, Power Generation; April 20, Industrial Power Systems.

ASME—The Semi Annual Meeting of The American Society of Mechanical Engineers will be held at the Hotel Statler, St. Louis, Mo., June 19-23.

ISA—The 1950 Instrument Conference and Exhibit of the Instrument Society of America, will be held in the Memorial Auditorium, Buffalo, New York from September 18-22.

CATALOG LIBRARY

This monthly list of the latest standard catalogs and bulletins is designed to aid the engineer in maintaining his permanent catalog file of engineering data. The items listed, unlike those under Helpful Bulletins, will appear each month except for additions and deletions determined by space requirements or by the manufacturers issuing the bulletins. Use the Helpful Bulletins coupon in requesting these copies.

BOILERS AND AUXILIARIES

201 **Working Pressure Data Card**—Maximum allowable working pressures for water tube and fire tube boilers are compiled in a handy reference table, Technical Data Card No. 113 A. It lists pressures in pounds per square inch for seamless and electric resistance welded carbon steel tubes or nipples for different diameters and gages of tubes conforming to ASME specifications. Chart covers 2 letter-size pages, is printed on firm stock, and punched for use in binder. The Babcock & Wilcox Tube Co.

202 **Dowtherm Vaporizer**—Bulletin No. 48-2, describing manufacturer's Type "A" Dowtherm Vaporizer tells how this unit is designed to evaporate dowtherm in such a way as to provide dependable operation at maximum temperatures, discussing its construction advantages in detail. It is illustrated with photos of the vaporizer and includes a dimensional drawing, vaporizer chart and specifications. Also included is table showing general properties of Dowtherm "A." The Wickes Boiler Co.

203 **Water Tube Boilers**—This 12-pp bulletin illustrates and describes special and standard power plant boilers and packaged steam generators. Includes data and dimensions. Springfield Boiler Co.

VALVES, TRAPS, PIPING

204 **Pipe Distribution System Data**—"Engineering Distribution Data for Underground Steam Distribution," is the title of Section 480-2, 34 pp, of practical usefulness to those who deal with problems involved in insulated piping distribution systems. It covers layout of the route and methods of estimating steam loads, includes steam flow charts and tables, and gives properties of steel pipe, copper water tube piping and saturated steam. Also gives specifications of steam and hot water distribution piping with prefabricated pipe conduit. It's illustrated with photos of field installations and industrial applications of insulated pipe units, also sketches showing method of making field closures. The Ric-Wil Co.

205 **Piping Materials Catalog**—Corrosion resistant valves and piping materials are covered in illustrated circular No. 320, 32 pp. Contains information on manufacturer's complete line of valves, fittings, fabricated piping and pipe coils to meet a wide range of corrosive conditions. Listing includes both photos and cutaway drawings of models, complete specifications, sizes and prices. Includes a description of alloy metals used and a corrosion questionnaire. Also included are several pages of condensed recommendations on the selection of piping materials according to service requirements as well as a pictorial chart showing basic types of valves with names of their component parts. Crane Co.

206 **Steam Specialties**—Here is a collection of bulletins covering manufacturer's line of thermostatic steam traps, inverted bucket steam traps, float-thermostatic steam traps, radiator traps and valves, alternating receivers and lift traps, self-operated temperature regulators, air venting equipment, water blenders, strainers. All equipment is illustrated by photos, its operation and applications discussed, and its capacities, dimensions and prices listed. Sarco Co., Inc.

207 **Pipe Hanger Catalog**—Ninety-page Catalog 10-D is a valuable buyer's guide for adjustable pipe hangers and supports. Covers hangers for attachments to pipe and to structure, hanger assemblies, spring hangers, hanger rods, pipe supports and related equipment. Each type described and illustrated by photo and di-

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mensional diagram and listed with dimensions and prices. Catalog also includes standard specifications, photos of installations and terms of sale. Indexed for quick reference; punched for filing in binder. Grinnell Co., Inc.

208 Valves Bulletin—A new catalog section 12-H describes all types of the company's cast steel pressure-seal bonnet valves. Information on choosing the best size valve for your service is given in one page of the booklet under the title, "Correlation of Valve Size and Pressure Drop." Design and construction advantages of the valves are given and tables of pressure and temperature ratings. Details of design including operating mechanism, body design, disk piston, and other features are explained. Dimensional details are given in tabular form accompanied by dimensioned line drawings. A standard materials specification table is presented. Edward Valves, Inc.

209 Rubber Expansion Joints — This 8 page bulletin AD 137 tells about the application, construction, styles, service and advantages of the company's line of rubber expansion joints. Other information given, includes "How To Order" and a table of dimensions which is accompanied by dimensioned line drawings. The bulletin is well illustrated. The Garlock Packing Company.

210 Control Equipment—General Catalog 001, 30 pp, is devoted to measuring and control equipment for water and sewage works, power and processing industries. Catalog illustrates and describes in detail: venturi tubes and meters, controllers, gages, manometers, pitot equipment. Includes capacity tables, dimensional data, specifications, layout drawings. Simplex Valve and Meter Co.

211 Flanges for Severe Service — This 4-pp bulletin describes and illustrates a flange specially developed for services involving severe abrasion and corrosives, and for use in suction and discharge service. Photos and sketches illustrate the flange and its parts. Bulletin also covers a flexible rubber pipe for use with abrasive or corrosive material, as well as an acid- and corrosion-resistant duct, listing solutions this duct will handle. Goodall Rubber Co.

HEATERS, HEATING

212 Fan Heater Bulletin—Here's a 2-pp illustrated bulletin (No. 109) on a new high pressure steam fan heater designed for complete utilization of both sensible and latent heat of high pressure steam. One page is devoted to description and photos of the heater. Other page contains a sketch in color showing how the heater works. Niagara Blower Co.

213 Space Heaters—Bulletin 523, 12 pp, covers forced air space heaters, direct-fired by oil, gas or combination fuel and ranging in output from 400,000 to 2,000,0000 Btu, for comfort heating, year-round ventilating, tempering make-up air, process drying and heat curing. It discusses their design and principle of heat distribution and lists 18 reasons why these heaters are recommended for open space heating. Includes specifications, capacity and dimension tables, sketches illustrating operating principles and construction details and photographs showing the heaters in use. Dravo Corp.

214 Packaged Heat — Unit heaters featuring low first cost, easy installation and continued low cost per Btu are presented in this 12-pp booklet. Text explains how these packaged heaters are designed to operate instantly on oil or gas, fit heat output to requirements of day, and provide heat where it's wanted. Illustrations include photos of heaters and several installations and many sketches showing advantages and construction details. Prat-Daniel Corp.

215 Tubular Heat Exchangers—Bulletin 916, 32 pp, is highly informative. The bulletin describes the present designs of the company's tubular heaters, coolers, condensers and heat exchangers and their distinctive features. The various types of shells, tube bundles, stationary heads and floating heads are fully explained, together with statements of the particular services for which each is suitable. An additional helpful feature of the bulletin are tables of the characteristics of tubing, the thermal resistance of tubes and pipes of many different metals and alloys, and the specific gravity and pounds per gallon corresponding to degrees Baume and API. Also presented are charts of specific heats of midcontinent crude oils and for solving MTD formula with correction factors

for other than countercurrent conditions. The Griscom-Russell Co.

216 **Chemical Soot Removal** — Ten-pp Bulletin 43, on the chemical removal of soot from boiler furnaces, explains the research work that led to the development of manufacturer's new chemical soot remover and slag alleviator for coal fired boiler furnaces. It tells how this combustion catalyst prevents soot formation on furnace internals and helps to end the smoke problem. National Aluminate Corp.

217 **Water Heaters**—Illustrated 6-pp Bulletin 70, Section I, on instantaneous type water heaters contains detailed capacity and dimension tables for two-pass, four-pass and six-pass designs, with tube bundles removable for inspection. A typical piping hook-up for installation of these heaters is shown. Also included are instructions for heater selection, engineering data to determine boiler capacities required for heating water, and a chart to determine pipe sizes for any steam flow at most pressures. Davis Engineering Corp.

218 **Tubular Heater**—A simplified vertical tubular heater suitable for every process duty and designed to hold initial and maintenance costs to a minimum, is the subject of 4-pp Bulletin 0-49-7. Includes a complete description of this simplified design which features the use of bare tubes and the absence of any metal parts exposed to furnace gases, also a discussion of the design's advantages. Cutaway drawings illustrate text. Foster Wheeler Corp.

219 **Condensate Drainage Control** — Manufacturer's system of high-pressure and high temperature condensate drainage control is fully explained in 24-pp Publication No. 3250. Contains useful data on steam flow conditions and heat exchange characteristics. Gives material and operating specifications and capacity ratings for both standard and high differential units in six sizes from 3 to 25 hp based on a maximum of 200 psi above process pressure. Differential pressures to 200 psi are listed and capacities for each unit tabulated for unit inlet pressures. Illustrations include photographs and dimensional drawings in color showing design and construction of both types of units. Cochrane Corp.

TREATMENTS, PREVENTIVES

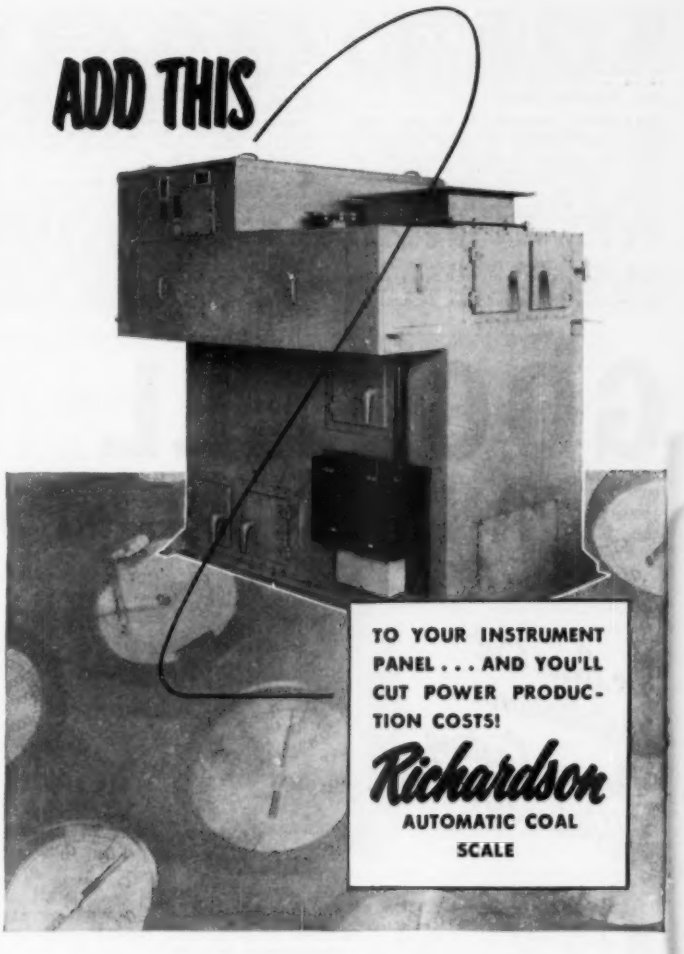
220 **Water Conditioning Bulletin**—This is an eight-page discussion of water and chemicals developed for conditioning it to control scale and algae and inhibit corrosion. Describes several chemicals in detail, giving properties, composition and application. Also discusses special purpose chemicals. Wright Chemical Corp.

221 **Corrosion Analysis**—Excellent working data on galvanic corrosion is contained in this 8-pp technical study of corrosion by concentration cells, reprinted from Inco Corrosion Reporter, Vol. 3, No. 1. Discusses concentration cells, the metal-ion cell type, oxygen cell type, reversible concentration cells, their practical aspects and some rules for minimizing or preventing concentration cell corrosion. Illustrated with sketches showing conditions which accelerate corrosion. The International Nickel Co., Inc.

222 **Corrosion Resistance of Nickel Alloys** —Technical Bulletin T-3 contains 44-pp of illustrated information on the resistance of high nickel alloys to corrosion by sulfuric acid. Although technical in nature, it is written so as to be readily understood by non-technical staffs. Performance of 30 nickel-bearing materials in a wide range of service is discussed, and there are 46 tables and 33 graphs and photos in addition to text. Problems involving a wide range of operations from the pickling of steel to petroleum refining and textile processing are covered. The International Nickel Co., Inc.

223 **Cleaning Industrial Equipment**—This is a general information bulletin on manufacturer's service for cleaning of steam generating, heat exchange and other industrial equipment. Also included is information on pipe line cleaning and water well acidizing. Illustrations of these services are included, and bulletin treats in detail the methods used to remove incrustations from internal surfaces economically with minimum of downtime. Dowell Inc.

224 **Anti-Foam Treatment** — This 4-pp bulletin covers a new formula in powder form to be applied along with anti-scale treatment for improving steam quality, controlling scale in boiler feed system and sludge conditioning. It discusses the



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problem of steam contamination and explains the action of this polyamide antifoam treatment. Tells how it should be applied and gives dosage requirements. A discussion of its advantages is accompanied by photos showing the effect of polyamide action on a boiling dilute Nacconol solution. Dearborn Chemical Co.

225 **Boiler Corrosion**—A 12 page article discussing the cause and prevention of corrosion in boiler systems is presented in Bets Technical Paper No. 111 titled "Corrosion: Its effect in Boiler Systems." The corrosive effects of oxygen, carbon dioxide, ammonia, hydrogen sulfide, acidity and physical factors are evaluated. Numerous illustrations, graphs and tables aid in understanding the article. W. H. & L. D. Betz.

226 **Turbine Blade Deposit Study**—Identification and prevention of steam turbine blade deposits and boiler water conditioning to prevent such deposits are discussed in the new 16-pp illustrated Bulletin 28B7030. Describes x-ray diffraction methods employed by the company for identification purposes and the results obtained. Tables list the partial chemical analyses of deposits containing sodium disilicate, occurence data on compounds found, composition of turbine deposits from turbines operating at various throttle pressures and temperatures, and comparison of compounds found in turbine blade deposits with boiler operating pressures. Allis-Chalmers Mfg. Co.

227 **Boiler Water Manual**—Factual information on standard methods of applying chemicals in the treatment of water for boilers is presented in this 16-page technical bulletin, called Standard Method 122. Discusses pretreatment of raw water, application of chemical feeding to pretreating operations and both constant rate and flow responsive feeding direct to boiler drum and to feedwater systems. Also discusses condensate returns, flushing periods, condenser cooling water treatment and chemical tanks. Illustrations include photographs of two feeders and diagrams of the various methods described. Punched for filing in ring binder. Proportioneers, Inc.

228 **Water Softener Equipment** — How the problems caused by hard water can be offset by the use of water softeners is explained in Bulletin 2386, 12 pp, describing ion exchange equipment. It covers in detail downflow, upflow and gravity zeolite water softeners. Contains a 2-pp cutaway illustration of a fully automatic softener to show how an ion exchanger is built and how it works. Bulletin also contains flow diagrams showing arrangements for installation of water softeners and includes detailed, illustrated discussion of multiport valves used in them. The Permutit Co.

229 **Corrosion Treatment** — "Corrosion Protection of Steam and Condensate Return Systems" is a 4-pp folder covering a recently developed amine treatment for inhibiting of boiler and condensate systems. This treatment is described as affording surface protection of the metal itself as well as raising the pH value of the condensate. Booklet gives specific case histories and typical economies obtained by power plants using this treatment. Includes graphs showing relationship between free CO_2, pH and alkalinity in water, and the solubility of oxygen in water when exposed to air at various pressures. The Bird-Archer Co.

230 **Chemical Feed Systems** — Single, complete "packaged" units for feeding directly into boiler feed water lines are the subject of 4-pp Bulletin 4911. It discusses in detail sodium sulfite feeding, internal treatment, chemical feeding, manual control, intermittent feeding of internal treating chemicals; automatic feed systems; automatic pH control, and automatic control by conductivity. Illustrations include photos and diagrams of controlled volume pumps and a typical packaged installation. Milton Roy Co.

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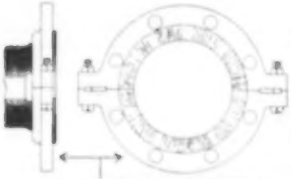

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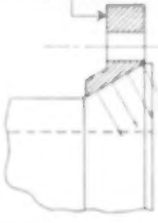

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ELECTRICAL

231 **Large D-C Motors**—Latest construction features of manufacturer's large d-c motors for applications requiring wide speed variation and fine speed control are discussed in 40-pp Bulletin OB56002A. Included is a comprehensive description of "frog leg" armature windings, a combination wave and lap winding that gives good commutation without cross-connectors and views of the new style mill-type spherical seated thrust bearing with welded-steel pedestal for heavy service. Controls for the motors, currently being used to drive metal rolling equipment, mine hoists, paper machines rubber mill rolls, plastic calendars and traction equipment are also covered. Allis-Chalmers Mfg. Co.

232 **Synchronous Generators**—This Bulletin, 05B6139A, describes construction features and electrical characteristics of engine-type synchronous generators in standard ratings from 25 to 10,000 kva and for standard speeds from 100 to 600 rpm, for Diesel, steam or gas engines. Also describes and illustrates mechanical construction of stators and rotors and discusses machine characteristics, ratings, voltages, frequencies, phases, temperature rises and operation at high elevation. Illustrations show typical installations. Available control accessories are listed, as are manufacturer's other products and territorial sales offices. Allis-Chalmers Manufacturing Co.

233 **Synchronous Motors** — High speed synchronous motors are described in this recently-issued 4-pp bulletin PB 5600-1. The bulletin is packed with descriptive matter and photographs explaining features of the motors rotor and stator. Mechanical modifications also are illustrated. Elliott Co.

234 **Mechanical Rectifiers** — Presenting mechanical rectifiers as a simple solution to the problem of low voltage power conversion. Bulletin 4809, 12 pp, covers their history and advantages, using charts and graphs as evidence of their inherent high efficiency. Also provides an illustrated explanation of rectifiers' operating principles. I-T-E Circuit Breaker Co.

PUMPS, COMPRESSORS, ENGINES

235 **Rotary Pumps**—Catalog LG, 4 pp, provides cutaway drawings and

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description of six different types of company's "IMO" rotary pumps, designed to handle residual and distillate fuel oils, crude oils, lubricating oils, viscous fluids and similar liquids. Discusses reliability, high speeds freedom from pulsation, accessibility and other advantages of these pumps in capacities ranging from 0.5 to 1000 gpm for pressures to 500 psi, and to 150 gpm for pressures to 1500 psi. DeLaval Steam Turbine Co.

236 **Steam Engine Governor Data**—This new bulletin No. 902, describes the company's Type E36 fully enclosed self-lubricated governor which is described as giving "precise, dependable engine speed control." Illustrations of the unit are presented and a parts list, accompanied by a sectional diagram is given. One section "Installation and Care" tells how to assemble governor to engine cylinder and how pulleys should be proportioned, the proper type of belt for use with the governor, correct lubrication procedure, method of packing and other data. Troy Engine & Machine Co.

237 **Condensers**—Bulletin 441-C, 28-pp, covers in detail every phase of manufacturer's line of condensers—their simplicity of design, accessibility, construction features. Illustrated with photos and drawings showing complete assemblies, parts, principles of operation. Bulletin also discusses emergency replacements, service and maintenance facilities available, and auxiliary equipment. Includes condenser tube data, pressure-conversion tables. Condenser Service & Engineering Co.

238 **Compressor Selection Chart**—Here's a new selection chart, based on normal applications handling air with atmospheric intake pressure. It simplifies selection of proper size compressor for average industrial use, with quick comparison between discharge pressure pounds per square inch gage and piston displacement cubic feet per minute and shows recommended compressor bore and stroke in inches. Chart covers two letter-size pages. Worthington Pump and Machinery Corp.

239 **Air Compressor Lubrication Manual**—Valuable information on air compressor maintenance is contained in this 40-page book on the lubrication of air compressors, second edition. Subjects treated include compressed air, compressors and related equipment, lubricating systems, compressor oils and their applications, lubrication requirements operating hints, oil requirements, storage and care of compressor oils, and safety precautions. All discussions are illustrated with large, clear photographs and drawings showing construction and operation of compressors, their lubricating systems, etc. Cities Service Oil Co. (In the South, Arkansas Fuel Oil Co.)

240 **Steam Pumps** — This is manufacturer's collection of bulletins covering all types of centrifugal and reciprocating pumps for a wide range of industrial uses. Contains more than 80 pp in all and includes photos, dimensions, specifications, ratings and application data. Warren Steam Pump Co.

INSTRUMENTS AND CONTROLS

241 **Smoke Density Recorder** — Bulletin 211, 4 pp, tells how company's bolometer-type smoke density recorder promotes efficient furnace operation and how it helps in the battle against smoke nuisance. It describes and illustrates the smoke detector which consists of a bolometer receiving and measuring radiation from a sealed beam light source. Recorder specifications, installation requirements, and measuring circuit details are also discussed. Bailey Meter Co.

242 **Boiler Water Level Control** — Bulletin 487 describes completely the installation of boiler water level control equipment at the Blackhawk Generating Station, Wisconsin Power & Light Company. Photographs of the installation are presented as is a schematic layout of the entire station along with tabulated significant data. A large, full-page cross section of the B & W Type FH integral furnace boiler is presented and other drawings and photographs show the accompanying equipment. Northern Equipment Company.

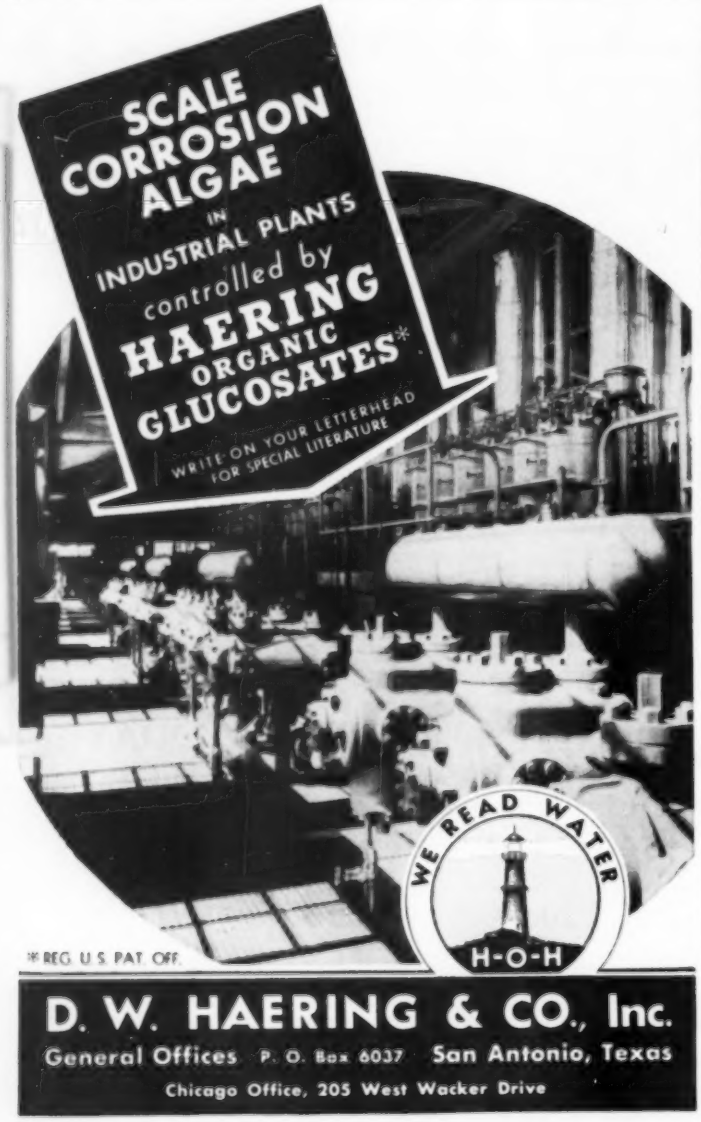
243 **Water Gages** — Eight-page Bulletin E-1 covers line of water gages for stationary and locomotive boilers, marine and refinery service and tanks for all pressures and temperatures. Listings include photos of all gages, sizes and construction details. Bulletin S-2, four pages, covers gage glasses, glass guards, sight flow indicators and related equipment. Ernst Water Column & Gage Co.

244 **Instrument Handbook**—"Modern pH and Chlorine Control" is a 100-pp catalog containing a great deal of valuable information in addition to covering manufacturer's line of scientific instruments and accessories. It explains the meaning of pH control, the electrometric and colorimetric methods of determining pH, and gives values of common acids, bases and foods, as well as maximum capacities of buffer systems. It also discusses in detail the applications of pH and chlorine control in air conditioning, water treatment, boiler water and many other industrial applications, recommending instruments and solutions. Instruments are illustrated by photograph, their functions described and prices given. W. A. Taylor & Co.

245 **Temperature Measuring Instruments**—For all those responsible for the safe operation of electric power equipment, this company has just issued a revised 34 page catalog ND4-33-461 describing the company's instruments for measuring the temperature of generators, motors, condensers, transformers, etc. The bulletin covers a wide variety of instruments, portable and automatic indicators, for checking in any order on temperatures. Reference also is made of new and specialized instruments for measuring in rapid succession a number of bearing temperatures. Leeds & Northrup Co.

246 **Recording Instrument Data Book**—An oxygen-analyzer, based on the para-magnetic property of oxygen, is described and illustrated in Bulletin 49-829, 16 pp. Tells advantages and applications of the instrument; also discusses manufacturer's analyzer for carbon dioxide and other gases and an electronic recorder (temperature and pressure) for use with analyzers. Describes several recommended gas sampling systems. The Hays Corp.

247 **Metering Chlorine** — Bulletin 640-F2 describes an instrument designed to accurately meter chlorine gas and deliver a chlorine water solution to the point of application. Discusses the safety and other features of the instrument and explains its operation and maintenance. Illustrations include photos, a phantom drawing showing principle working parts, and a layout diagram. Builders-Providence, Inc.



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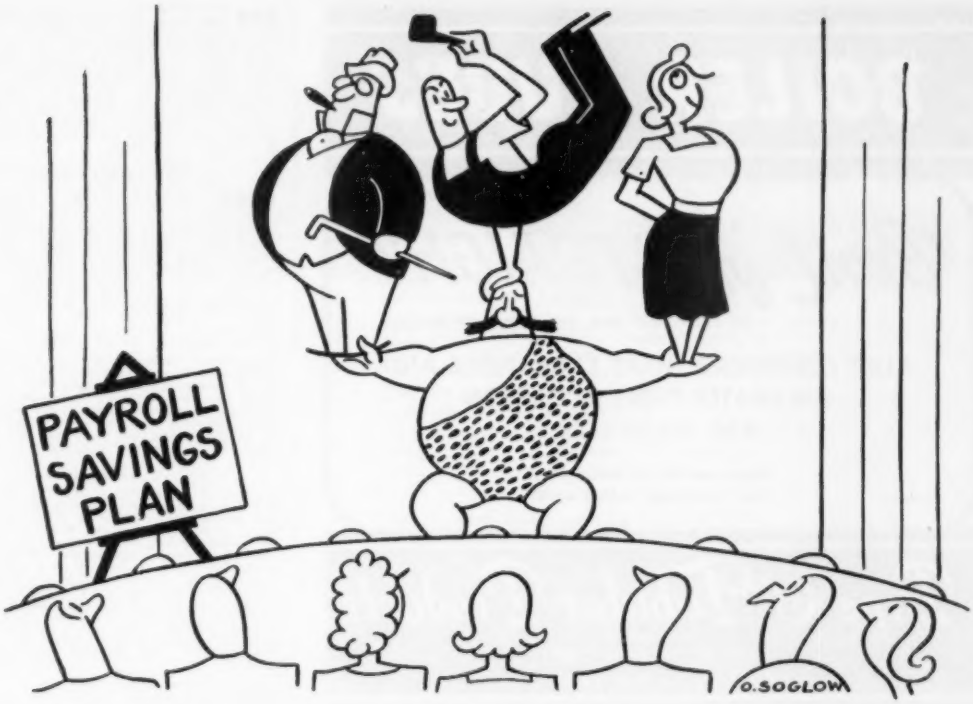

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248 **Purity Indicator**—An instrument for measuring and indicating electrical conductance of steam and water is described and illustrated in 6-pp Bulletin 11-23-48 RCU. It discusses problems encountered with steam and condensate purity and cites examples of how controller and alarm assembly are utilized in detecting and signalling impurities caused by carry-over and condenser leakage. Includes photos of typical test apparatus, also prices. E. F. Drew & Co., Inc.

MATERIALS HANDLING

249 **Dry Materials Conveyor** — Bulletin F-H-1 describes this company's revolutionary type of conveyor designed for the handling of fine, dry materials. The book, which contains 12 pages, presents excellent installation views of the conveyor, and also drawings which illustrate construction and method of operation. The bulletin points out that the conveyor has no moving parts and that it has no hazards to workmen, is silent in operation, requires no lubrication and can pass around obstacles. Fuller Company

250 **Screw Conveyor**—Two-pp Form A-84 describes a high-speed, direct-feed, bin-to-stoker screw conveyor that comes ready to set up. Illustrations show this conveyor in use and detail of its principal parts. Stresses economy of this conveyor in handling coal and includes specifications. Baughman Mfg. Co., Inc.

COAL HANDLING

251 **Coal Scale Data Book**—The answers to a power engineer's questions on coal scales are provided in this excellent 48-pp book, Bulletin 1143, covering scales for recording weight of coal consumed by individual boilers and weight of coal receipts from ship, car, truck or storage. It is generously illustrated with photographs of models and accessories and actual plant installations and contains all necessary engineering drawings, dimensional data and detailed specifications. Construction features and operation of weighing and feeding systems are described. Richardson Scale Co.

252 **Spreader Stoker Selection** — Fourteen-pp Form P-320-A10M is intended to help those choosing a spreader stoker to get the most for their investment, and it points out many factors to be considered in the selection. It pictures and describes in detail the principle operating parts of manufacturer's stokers, emphasizing their advantages. Includes engineering drawings and photos of typical installations. American Engineering Co.

253 **Coal Crushing, Sizing** — Bulletin 3007 describes the company's Bradford breaker a coal crusher, sizer and scavenger. The bulletin presents drawings of the breaker, tells how it works and then presents the complete story of its operation at the coal mine and coal cleaning plant at the By-Product Coke Plant and at the Power Station. The back section of the catalog presents engineering information on capacities, dimensions and dimensioned line drawings. Pennsylvania Crusher Co.

254 **Coal Crusher**—In this 8-pp bulletin a rolling ring crusher is presented as a solution to the problem of uniform stoker coal. Describes the special features of this crusher, emphasizing its shredder designed to split coal rather than crush it. Gives speed, capacity, weight and dimensions of available models and illustrates principle of operation. Also contains photos of parts and several complete installations. American Pulverizer Co.

255 **Underfeed Stokers**—Buletin 350, 24 pp, features a single retort underfeed stoker which may be operated by electric or steam drive. It is described as a complete firing unit for burning various grades of bituminous coal with high efficiency for boilers from 50 to 150 hp rated capacities. Generously illustrated, the bulletin explains the operation of these stokers, tells their applications and economy and gives sizes and capacities. Also contains installation photos and diagrams. Detroit Stoker Co.

TURBINES

256 **Turbine Catalog Collection**—This is a valuable collection of bulletins in loose-leaf form. They cover a complete description of manufacturer's solid wheel turbines and feature cross section drawings of typical units for both moderate and high steam pressure conditions. Also provides a description of an axial flow impulse, both single and multi-stage, and complete data on speed increasing and speed reduction gears. The Terry Steam Turbine Co.

257 **Velocity Stage Turbines** — Catalog 52-19R, 8 pp, features turbines for mechanical drives designed to operate under all inlet steam conditions up to 600 psig and 750 F. Gives complete specifications, dimensions and includes chart showing how to estimate turbine sizes. Illustrations include cutaway view, photos of parts, speed governor and regulating valve, and emergency governor and trip valve are described in detail. De Laval Steam Turbine Co.

258 **The Answers on Turbine Oil**—This 12-pp booklet answers several questions power engineers ask about turbine oils, including: What causes deposits of sludge? What causes acidty increase? What causes corrosion in turbines? Explanations are brief but thorough. Booklet is illustrated with photos of turbine installations in which manufacturer's products have been used successfully. Standard Oil Co. (Indiana).

MISCELLANEOUS

259 **Pump Packings**—Packings for use on reciprocating and centrifugal pumps are illustrated by photo and described in this 4-pp folder. It covers packings for practically all services and includes a table of recommendations to facilitate selecting the right packing for any particular application. Johns-Manville.

260 **Cooling Towers**—Double-flow cooling towers are featured in 20-pp Bulletin DF. It discusses the principle of double-flow cooling, the mechanical equipment utilized, construction features of a tower of this type, water distribution, coil shed, and safety factors. Recommends sizes for different applications and includes photos of many installations. The Marley Co., Inc.

261 **Concrete Floors Q & A** — A new booklet titled Lumnite Concrete Floors—Corrosion Resistant and Heat Resistant, has just been published. The detailed information contained in this booklet brings up to date, the service experiences and late developments in this field. The information covers methods and materials used in placing corrosion resistant concrete in a wide variety of industrial applications. Typical uses of corrosion resistant concrete are listed for many industries and also given, are the answers to a number of questions often asked about it. A section on placing and finishing corrosion resistant floors will be helpful to prospective users. Lumnite Division, Universal Atlas Cement Company.

262 **Application Data Bulletin** — Titled "The Aroclors," chlorinated biphenyl and chlorinated poly-phenyls, this booklet describes the unique properties which enables this material to fulfill certain requirements. The Aroclors have won a place in the electrical insulating field and in such widely differing applications as non-flammable hydraulic media, high-temperature and high-pressure lubricants, heat-transfer and expansion media, sealing compounds, adhesives and protective coatings, including plastics, pigments, lacquers, paints and varnishes. This booklet contains 28 pages and presents the combined information gathered by the company from what it believes to be reliable and dependable sources. Monsanto Chemical Co.

263 **Tube-Ice Machine** — Bulletin TI-3 describes manufacturer's automatic ice-making machine for producing either cylinder or crushed ice. Explains and illustrates machine's operation, discussing its small space requirement, quick freezing time, reduced power consumption and economy. Its application in the dairy and packing industries, breweries, chemical plants, institutions, and ice plants are described and pictured. Also discussed is the utilization of this machine in cold water refrigeration for air conditioning systems. Includes chapter on the handling and storage of ice. Henry Vogt Machine Co.

264 **Purger Bulletin**—How air and other non-condensables get into refrigeration systems; the adverse effect of this on operating costs and efficiency and what manufacturer's forged steel purger does to prevent it are covered in 8-pp Bulletin 192. Also included are installation data with illustrations and diagrams, specifications and prices, helpful charts and tables. Armstrong Machine Works.

265 **Water Hardness Test**—This technical bulletin presents a test procedure for determining hardness of water, by use of a color indicator which is described as both easy and accurate. Instructions for running the test are illustrated in color. Includes prices of company's complete hardness titration set and individual solutions used. W. H. & L. D. Betz.

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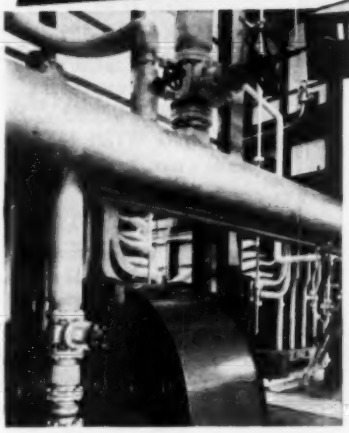

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266 Dust Collectors — Dust collecting equipment for power plants, foundries, cement plants and similar industries is the subject of Bulletin No. 1438, 36 pp. Contains many photographs of installations, also photos showing equipment being tested in company laboratories. Discusses services offered by manufacturer in analyzing individual installation requirements and recommending equipment for the job. American Blower Corp.

267 Hoisting Towers—Tubular steel towers for heavy and light duty hoisting service are described in this 4-pp bulletin. Sketches showing tower assembly and parts and illustrating construction features are included. Gives load capacities of both types, lists optional equipment. Manufactured by Beaver Art Metal Corp., Distributed by Dravo Corp.

268 Reference Bibliography for Water, Sewage and Power Plant Engineering—This 36 page, paper bound bulletin consists of a comprehensive and up-to-date listing of the best available sources of information on use of water for drinking and also for boiler feedwater supply; on sewage treatment and industrial waste treatment; and on power plant design and operation. The bibliography lists first a number of books and magazines covering water supply, treatment, treatment plant design and operation. Next, publications on the bacteriology of water and sewage. Third, publications covering sewage and industrial waste treatment and chemistry and analysis of water and sewage. Fourth, publications on power station design, operation and equipment and finally standard engineering handbooks, data and aid for hydraulic and power engineering. A list of foreign publications is also given. Also a list of periodicals on chemical laboratory procedure, water and sewage, and a good list of manufacturers publications. Published by Gilbert Associates, Inc.

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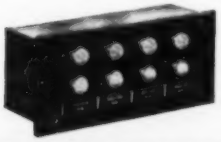

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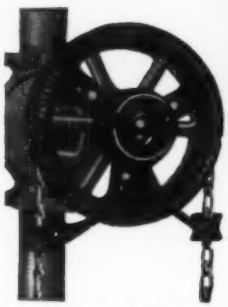

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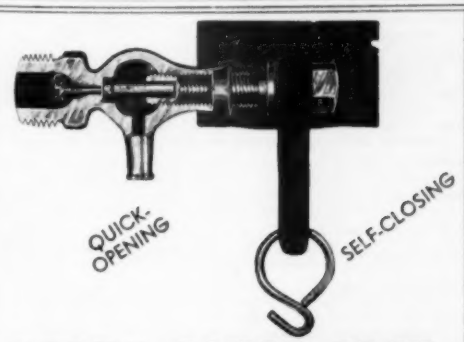

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Agency—Russell T. Gray, Inc.
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Agency—Paul L. Kuch Advertising
Babcock & Wilcox Co., The 41
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Baughman Manufacturing Co., Inc. ..... *
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Belmont Packing & Rubber Co., The 104
Agency—McNevin-Wilson-Daldorf, Inc.
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Bird-Archer Co., The ..... *
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Agency—Willard G. Myers Advertising Agency
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Agency—G. M. Basford Company
Condenser Service & Engineering Co., Inc. 112
Crane Co. 43
Agency—The Buchen Company
Dart Mfg. Co., F. M. ..... *
Agency—Sutherland-Abbott
Davis Engineering Corporation ..... *
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Dearborn Chemical Company ..... *
Agency—The Fensholt Company
DeLaval Separator Co., The 97
Agency—Donahue & Coe, Inc.
DeLaval Steam Turbine Co. 110
Agency—Geo. H. Gibson Co.
Detroit Stoker Company ..... *
Agency—Witte & Burden
Dowell Incorporated 37
Agency—MacManus, John & Adams, Inc.
Drew & Co., Inc., F. F. 49
Agency—The Aitken-Kynett Co.
Edward Valves, Inc. 9
Agency—Gebhardt & Brockson, Inc.
Elliott Co. 2-3
Agency—Peterson & Kempner, Inc.
Engineer Co., The 87
Agency—Michel-Cather, Inc.
Erie City Iron Works ..... *
Agency—Davies and McKinney
Ernst Water Column & Gage Co. 116
Agency—Lesky Company
Everlasting Valve Co. ..... *
Agency—Michel-Cather, Inc.
Fluor Corporation, Ltd. ..... *
Agency—Dozier, Graham, Eastman
Foster Engineering Company ..... *
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Foster Wheeler Corp. 26-27
Agency—Albert Frank-Guenther Law, Inc.
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General Electric Company ..... *
Agency—G. M. Basford Company
Gifford-Wood Co. 32
Agency—O. S. Tyson and Company, Inc.
Golden-Anderson Valve Specialty Co. 38
Agency—Walker & Downing
Goodall Rubber Co., Inc. 106
Agency—George C. Taylor
Graver Water Conditioning Co. ..... *
Agency—Michel-Cather, Inc.
Grinnell Co., Inc. 33
Agency—Horton-Noyes Co.
Griscom-Russell Co., The 24
Agency—Michel-Cather, Inc.
Haering & Co., Inc., D. W. 108
Agency—Brandt Advertising Company
Hagan Corporation 31
Agency—Ketchum, MacLeod & Grove, Inc.
Hall Laboratories, Inc. 19
Agency—Ketchum, MacLeod & Grove, Inc.
Hays Corporation, The 103
Agency—Gebhardt & Brockson, Inc.
Hays School of Combustion 112
Agency—Kreicker & Meloan, Inc.
Huyette Co., Inc., The Paul B. 113
International Nickel Co., Inc., The ..... *
Agency—Marschalk & Pratt Co.
Johns-Manville ..... *
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Kellogg Co., The M. W. ..... *
Agency—Gordon Baird Associates, Inc.
Leeds & Northrup Company 12
Agency—Geare-Marston, Inc.
Link-Belt Co. 25
Agency—Don Proctor Advertising
Lovejoy Flexible Coupling Co. 113
Agency—Symonds, MacKenzie & Company, Inc.
Manning, Maxwell & Moore, Inc. ..... *
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Agency—Witte & Burden
Milton Roy Company ..... *
Agency—Walter S. Chittick Company
National Aluminate Corporation 34
Agency—Armstrong Advertising Agency
National Power Show ..... *
Agency—The Biddle Company
National Valve & Mfg. Co. ..... *
Niagara Blower Co. ..... *
Agency—The Moss-Chase Company
Nicholson & Co., W. H. 111
Agency—Wilbur A. Myers
Northern Equipment Company 51
Agency—Davies and McKinney
Pacific Pumps, Inc. ..... *
Agency—The McCarty Company
Panellit, Inc. 113
Agency—Armstrong Advertising Agency
Pennsylvania Crusher Co. ..... *
Agency—McLain-Dorville, Inc.
Permutit Co., The ..... *
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Pipe & Tubular Products, Inc. 110
Prat-Daniel Corp. ..... *
Agency—The Harry P. Bridge Company
Pritchard & Co., J. F. ..... *
Agency—Carter Advertising Agency, Inc.
Proportioneers, Inc. 6
Agency—Hammond-Goff Co.
Reliance Gauge Column Co., The ..... *
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Stets Company ..... *
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Agency—Gray & Rogers
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Agency—Emery Advertising Corporation
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Warren Steam Pump Co., Inc. 22
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Western Precipitation Corp. ..... *
Agency—Dozier-Graham-Eastman Advertising
Wheeler Mfg. Co., C. H. 40
Agency—Eugene A. Holland
Wickes Boiler Co., The 89
Agency—Price, Hedrick & Tanner, Inc.
Wilson, Inc., Thomas C. 115
Agency—Michel-Cather, Inc.
Wing Mfg. Co., L. J. ..... *
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TW-772

WILSON TUBE CLEANERS

POWER PLANT CONSTRUCTION NEWS

(Continued from page 50)

Bedford, Mass., is head of new company. Erection will begin soon.

Cascade Locks, Ore.—Columbia Electro-Chemical Phosphate Co., Cascade Locks, plans steam power house in connection with new local plant, entire project to cost about $450,000. Galvin Wolfe is engineer.

Portland, Ore.—State Bd. Control, Capitol Bldg., Salem, Ore., plans boiler plant for central-heating service in new 10-story state office building to cover an entire block at S. W. Columbia and Clay Sts., Portland. Entire project estimated to cost about $2,500,000. Bids will be asked early in 1950. Dougan, Heims & Caine, Terminal Sales Bldg., are architects; and Thomas E. Taylor, Spalding Bldg., mechanical engineer, both Portland.

Cheyney, Pa.—General State Authority, 18th and Herr Sts., Harrisburg, Pa., has authorized plans for new power plant for central-heating service at Cheyney Training School for Teachers. Cost estimated about $450,000, with boilers and auxiliary equipment. Engineering department, A. F. Jones, chief engineer, will be in charge.

Johnstown, Pa.—Pennsylvania Electric Co., has arranged financing in amount of about $11,000,000, through sale of bond issue, considerable portion of proceeds to be used for expansion and improvements in power plants and system, including increased generating facilities, transmission lines, power substations, etc.

Philadelphia, Pa.—Board of Education, 21st and Winter Sts., plans boiler plant for central-heating service in new multi-story high school at South Philadelphia. Entire project estimated to cost $5,000,000. Proposed to begin work soon. Davis, Dunlap & Carver, 1717 Sansom St., are architects; Gravell & Duncan, 1600 Walnut St., are engineers, both Philadelphia.

Slippery Rock, Pa.—General State Authority, 18th and Herr Sts., Harrisburg, Pa., has authorized plans for new boiler plant for central-heating service at State Teachers' College, Slippery Rock, estimated to cost approximately $650,000, with boilers, pumps and auxiliary equipment. Engineering department, A. F. Jones, chief engineer, will be in charge.

Cranston, R. I.—Board of Education plans boiler plant for central-heating service in new 2-story and basement junior high-school in vicinity of Roger Williams Park. Entire project estimated to cost about $1,500,000. Bids for erection are expected to be asked soon. Creer, Kent, Mather, Cruise & Aldrich, Industrial Bldg., Providence, R. I., are architects.

Fort Worth, Texas—Community Public Service Co., Electric Bldg., has plans for extensions and improvements in steam-electric generating station. An additional turbine-generator and auxiliary equipment will be installed. Work is scheduled to be placed under way soon.

Galveston, Texas—Thomas J. Lipton, Inc., 1500 Hudson St., Hoboken, N. J., teas and other food products, a subsidiary of Continental Foods, Inc., same address, plans boiler plant at proposed new branch factory on Ave. A, Galveston, where site has been acquired. Entire project is reported to cost over $650,000. Proposed to begin work early in 1950.

Houston, Texas—Stauffer Chemical Co., M. & M. Bldg., industrial and other chemicals, plans boiler house at proposed new plant on 10-acre tract of land on Hempstead Rd. Entire project reported to cost about $1,500,000. Work is expected to begin soon. Main offices are at 420 Lexington Ave., New York, N. Y.

Houston, Texas—United Creosoting Co., 1704 Oliver St., is reported planning new steam power house in connection with proposed creosoting plant on tract of about 60 acres of land near city. Entire project is estimated to cost about $500,000.

Laredo, Texas—Central Power & Light Co., Corpus Christi, Texas, has plans nearing completion for new generating station in vicinity of Laredo, reported to cost about $600,000. It is understood that Diesel engine-generator units will be installed. Proposed to begin work at early date.

Charlottesville, Va.—State Board of Education, State Office Bldg., Richmond, Va., plans new boiler house at University of Virginia, for central-heating service. Cost estimated about $550,000, with boilers, pumps and auxiliary equipment. Plans are scheduled to be prepared soon.

Scottsville, Va.—Old Dominion Electric Cooperative, Inc., South Hill, Va., plans electric generating station in vicinity of Scottsville, where site has been selected. Estimates of cost and details will be determined soon. Arrangements are being made for financing.

Point Wells, Wash.—Stancal Asphalt & Bitumuls Co., 200 Bush St., San Francisco, Calif., plans power plant at proposed new asphalt refinery at Point Wells, near Seattle, where site has been selected. It will comprise several production units. No official estimate of cost announced. Work is expected to begin early in 1950. Company is a subsidiary of Standard Oil Co. of California, Inc., first noted address.

Fairmont, W. Va.—Monongahela Power Co., Watson Bldg., plans expansion in Rivesville steam-electric generating station, with installation of additional turbine-generator, high-pressure boilers and auxiliary equipment. Entire project estimated to cost about $12,500,000, with switching station facilities, transmission lines, etc.

Wellington, New Zealand—State Hydro-Electric Dept., Wellington, will receive bids until March 28, 1950, for four 44,444-kva electric generators (Contract No. 133), and until April 4, 1950, for four 56,000-hp hydraulic turbines (Contract No. 132) for installation in Roxburgh hydroelectric power station on Clutha River, South Island, N. Z. Also, until April 18, 1950, for four 44.4-mva transformer banks (Contract No. 119). Plans and specifications on file at office noted, and on loan basis from Commercial Intelligence Branch, Dept. of Commerce, Washington, D. C.

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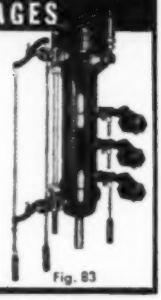

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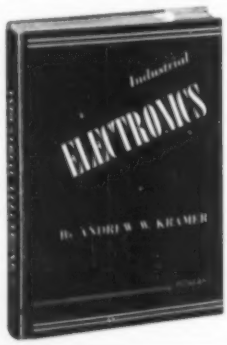

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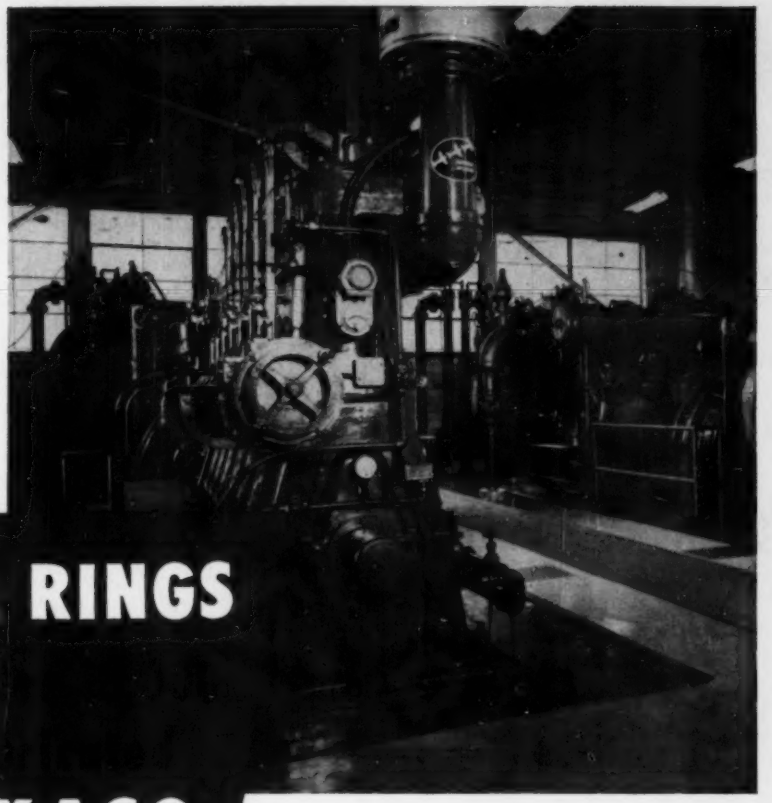
The Chapman Valve Manufacturing Company
INDIAN ORCHARD, MASSACHUSETTS



Power plant of Republic Aviation Corporation, Farmingdale, N. Y. Texaco Ursa Oil has lubricated one of these 300-h.p. Chicago Pneumatic Diesels for eight years and the other for seven years.

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